PB-229 726

GUIDELINES FOR REVIEW OF ENVIRONMENTAL IMPACT STATEMENTS. VOLUME I. HIGHWAY PROJECTS

ENVIRONMENTAL PROTECTION AGENCY

SEPTEMBER 1973

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

PB 229 726

GUIDELINES FOR REVIEW OF ENVIRONMENTAL IMPACT STATEMENTS

Volume 1

HIGHWAY PROJECTS

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF FEDERAL ACTIVITIES

September 1973

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-229 726
4. Title and Subtitle Guidelines for Review of Environmental Impact Statements, Volume: Highway Projects			5. Report Date Sept. 1973, Date of issue 6.
7. Author(s) William D. Dickerson			8. Performing Organization Rept. No. N/A
9. Performing Organization Name and Address Environmental Protection Agency, A-104 Office of Federal Activities 401 M St. S.W., Rm., 537 WT Washington, D.C. 20460			10. Project/Task/Work Unit No. N/A 11. Contract/Grant No. N/A
12. Sponsoring Organization Name and Address Environmental Protection Agency, A-104 Office of Federal Activities 401 M St. S.W., Rm., 537 WT Washington, D.C. 20460			13. Type of Report & Period Covered Final 14.

15. Supplementary Notes

16. Abstracts

This volume presents detailed guidance for the assessment of the primary air, water, noise, and solid waste management impacts from highway projects at the route location stage of highway development.

17. Key Words and Document Analysis. 17a. Descriptors

Environmental Impact Statement
Highways
Air Pollution
Noise Pollution
Water Pollution

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	UNCLASSIFIED	80
	20. Security Class (This Page) UNCLASSIFIED	22. Price $4.00

PREFACE

This volume presents detailed guidance for the assessment of the primary impacts from highway projects at the route location stage of highway development.

In its current form, this volume is intended to serve as a supplement to Environmental Protection Agency Order 1640.1 and existing assessment techniques related to secondary impacts and transportation system alternatives. In toto, these documents provide the detailed framework for the Environmental Protection Agency review of Federal-aid highway-project environmental impact statements.

As additional or refined review techniques and assessment procedures become available, this document will be reissued or revised as necessary. Note, however, that *only the numbered copies are on the distribution list for revised materials.*

Comments and suggestions regarding this document should be directed to the attention of Director, Office of Federal Activities, Environmental Protection Agency, Washington, D.C. 20460.

Preceding page blank

CONTENTS

		Page
Preface		iii
List of Illustrations		vii
I.	Introduction	1
II.	Review of Highway-Project Environmental Impact Statements	5
III.	Project Description	9
IV.	Probable Impact of the Proposed Project	11
IV.A.	Air Impact Review	12
IV.A.1.	Highway-Related Air Pollutants	12
IV.A.2.	Review of Air Impact Analysis	14
IV.A.3.	Assessment of Air Impact	21
IV.B.	Water Impact Review	29
IV.B.1.	Highway-Related Water Impacts	29
IV.B.2.	Review of Water Impact Analysis	30
IV.B.3.	Assessment of Water Impact	31
IV.C.	Noise Impact Review	35
IV.C.1.	Highway-Related Noise Criteria and Standards	35
IV.C.2.	Review of Noise Impact Analysis	36
IV.C.3.	Assessment of Noise Impact	38
IV.D.	Solid Waste Management Impact Review	40
IV.D.1.	Highway-Related Solid Waste Management Impacts	40
IV.D.2.	Review of Solid Waste Management Impact Analysis	40
IV.D.3.	Assessment of Solid Waste Impact	41
V.	Relationship Between Local Short Term Uses of Study Area and the Maintenance and Enhancement of Long Term Productivity	43
VI.	Irreversible and Irretrievable Commitments of Resources Involved in the Proposed Project	45
VII.	Probable Adverse Impacts that Cannot Be Avoided	47
VIII.	Alternatives to Proposed Action	49
References		51

Preceding page blank

CONTENTS–(Continued)

		Page
Appendix A.	Air Quality Control Regions That Included Transportation Controls as Part of Their SIP	55
Appendix B.	Air Impact Forecast Procedure for Carbon Monoxide	57
Appendix C.	General Concepts of Traffic Flow and Speed Characteristics	61

LIST OF ILLUSTRATIONS

Table — Page

1 Highway-related national ambient air quality standards 13
2 Traffic parameters for emission estimates 17
3 Level of analyses adequate for estimating the air quality impacts from highway projects 23

Figure

1 FIS review process 7
2 Air analysis review sequence 15
3 Examples of emission growth trends 26
4 Example CO concentration patterns for a given highway segment 26
5 Noise analysis data and methodology 37
B-1 CO quantification as a function of impact 59
C-1 General concept of relationship of levels of service to operating speed and volume/capacity ratio 62
C-2 Example variation of hourly traffic 64
C-3 Example hourly variations of traffic for average weekday 65
C-4 Example hourly variations of daily traffic 66
C-5 Example daily changes in traffic 67
C-6 Examples of monthly traffic volume variations 68
C-7 Relation of hourly volumes and annual average daily traffic 69
C-8 Example traffic volume variation between lanes (six-lane facility) 70
C-9 Total motor-vehicle travel and forecast for a selected state 70
C-10 Example diurnal variation in volume and speed 73
C-11 Typical relationship between volume per lane and operating speed in one direction of travel under ideal uninterrupted flow conditions on freeways and expressways 74
C-12 Relationship between v/c ratio and operating speed, in one direction of travel, on freeways and expressways, under uninterrupted flow conditions 75

I. INTRODUCTION

Section 102(2)(C) of the National Environmental Policy Act of 1970 stipulates that

> Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes; . . .

In view of the legal jurisdiction of and special expertise within EPA, this section obligates Federal agencies to obtain comments from EPA wherever an action related to air or water quality, noise abatement, solid waste disposal, generally applicable environmental radiation criteria and standards, or other provisions of the authority of EPA are involved. In addition, section 309 of the Clean Air Act Amendments of 1970 gives EPA the explicit legal mandate to comment in writing on the environmental impact of any matter relating to EPA's duties and responsibilities.* Section 309 provides

> (a) The Administrator [of EPA] shall review and comment in writing on the environmental impact of any matter relating to duties and responsibilities granted pursuant to this Act or other provisions of the authority of the Administrator, contained in any (1) legislation proposed by any Federal department or agency, (2) newly authorized Federal projects for construction and any major Federal agency action (other than a project for construction) to which Section 102(2)(C) of Public Law 91-190 applies, and (3) proposed regulations published by any department or agency of the Federal Government. Such written comment shall be made public at the conclusion of any such review.
>
> (b) In the event the Administrator determines that any such legislation, action, or regulation is unsatisfactory from the standpoint of public health or welfare or environmental quality, he shall publish his determination and the matter shall be referred to the Council on Environmental Quality.

To implement this responsibility, EPA Order 1640.1 has established detailed policies, responsibilities, and administrative procedures for the Agency's review of Federal actions impacting the environment. This order provides that, where an environmental impact statement (EIS) has been sent to EPA for comment, EPA's comments on the EIS shall also constitute its comments for purposes of section 309.

Because 1640.1 does not include procedures for the technical review of EIS's, the Office of Federal Activities, in conjunction with program and regional offices, is in the

*A listing of relevant legislation, Executive orders, and Office of Management and Budget circulars and bulletins may be found in "Basic Documents Concerning Federal Programs to Control Environmental Pollution from Federal Government Activities."[1]

process of preparing detailed review guidelines for several major project categories. The guidelines presented here are the initial volume.

The review of highway-project EIS's is complicated by the fact that the highway EIS's are issued at a rather late period within the total highway-planning process. While this procedure does provide for a detailed impact assessment of the particular project, it does not lend itself to an adequate assessment of the transportation system design that spawned the project.

The highway-planning process generally involves the following four planning stages:

- *Transportation planning* involves the development of all facilities used for the movement of persons or goods and, specifically, leads to the specification of the highway portion of the overall plan.

- *Systems planning** starts with transportation data defining the highway system within the corridor and develops "system factors," such as corridor termini, forecast demand on the facility, projected land use in the corridor, desired level of service, and desired interchange system.

- *Route location* then applies detailed local area considerations to select the preliminary location, basic type of roadway, number of lanes, and basic interchange design. This selection process usually involves a large number of technical, social, and economic effects.

- *Final design* results in the completion of the process by producing the precise roadway and interchange characteristics.

Under procedures for the implementation of the National Environmental Policy Act, FHWA marks the "route location" as the point at which an EIS is to be prepared and circulated for comment.† Typically, such project-level EIS's have not addressed the larger questions of alternative transportation modes, alternative corridor locations, or the synergistic effect of the proposed roadway when combined with future projects. It is apparent that these considerations are fundamental to the effort of minimizing the total tansportation-related impact on a given region. The review of a project-level EIS should include a comprehensive assessment of all of the foregoing planning stages.

To accomplish this objective, however, two things must occur. First, project-level EIS's will have to be direct products of transportation and systems plans that have been assessed by EPA. The EIS review could then focus exclusively on the environmental impact at the location/design stage. Second, EPA reviewers must have adequate guidance for conducting environmental reviews at the transportation-planning level. Review guidance specific to the

*In some Federal Highway Administration (FHWA) publications systems planning is defined to include transportation planning.

†In cases where the subsequent final design planning dictates ". . . a new or changed environmental effect of significance," FHWA requires an additional or supplemental impact statement ". . . to be processed in the same manner as a new environmental statement."[2]

transportation- and systems-planning stages are being developed and should be available within the next year.

In recognition of the need for environmental assessments throughout the highway-planning process, section 109(h) of the Federal-Aid Highway Act of 1970 requires that "possible adverse economic, social, and environmental effects relating to any proposed project on any Federal-aid system have been fully considered . . . ." Pursuant to this requirement, the FHWA has issued process guidelines[3] requiring an action plan from each State highway agency. Each plan must define the State's planning process for Federal-aid highway projects, and set forth how the proposed projects will be derived from the transportation- and systems-planning stages. In addition, the specific involvement of EPA at each planning stage will be defined.

Because it will be some time before the action plans are implemented fully, EPA can expect to continue to receive impact statements without the transportation-level considerations before described. The reviewer should continue to insure that the project-level EIS's have *considered* appropriate transportation-planning alternatives.

The highway-related impact areas for which EPA has special expertise include air quality, water quality, noise levels, and solid waste management. The review must assess the impact in these areas as they occur, directly through the construction and operation of the project and indirectly through increased activity induced by the project. Unfortunately, the quantification and assessment techniques necessary for an adequate review of the induced or "secondary" effects are not well understood. Several studies are currently in progress[4,5] that should provide at least the basic methodology for assessment of the secondary impacts.

Within the foregoing context, then, the review procedures in these guidelines are specific to assessment of the primary air-, water-, noise-, and solid-waste-management-related impacts from highway projects at the route-location stage of development. Until the transportation-planning and secondary impact studies are completed, the reviewer must continue to utilize his own resources for reviews in these areas. The final project assessment should reflect both primary and secondary impact considerations.

In any case, it is imperative that EPA provide meaningful and constructive comments on all draft EIS's received for review. If the reviewer feels that a statement is inadequate or lacking in proper scope, an explanation of the inadequacies should be given. Such explanations should include detailed commentary that outlines both the information required and the reasons why this information is needed to do a comprehensive environmental analysis.

II. REVIEW OF HIGHWAY—PROJECT ENVIRONMENTAL IMPACT STATEMENTS

While the purpose of the review is to assess the environmental impact of the proposed project, it is also obviously necessary to assess the completeness (i.e., adequacy) of the material presented in the environmental impact statement (EIS). It is emphasized, however, that the main objective of the EPA review is to assess the impacts related to air, water, noise, and solid waste management, and not to critique the way in which the EIS is organized or written.

In determining the adequacy of the EIS, the reviewer must consider both the material presented in the EIS and the material presented in reference documents. According to the Council on Environmental Quality (CEQ) guidelines for preparation of impact statements,[6] "Highly technical and specialized analyses and data should be avoided in the body of the draft impact statement. Such materials should be attached as appendices or footnoted with adequate bibliographic references." In what follows, then, the term *"EIS" is used in the generic sense of "EIS and referenced technical documents," provided that, first, the EIS contains adequate summaries of the methodologies and results of the various technical analyses, and, second, the detailed reports describing these methodologies and results are available.*

The reviewer should note, however, that the foregoing does not preclude the requirement that the EIS itself contain sufficient "information, summary technical data, and maps and diagrams, where relevant, adequate to permit an assessment of potential environmental impact by commenting agencies and the public."[6]

EPA Order 1640.1 provides for assignment of separate ratings for the environmental impact of the project (designated by LO, ER, or EU), and for the adequacy of the EIS (designated by 1, 2, or 3). The procedure for assigning a rating is as follows:

1. If sufficient information is available in the EIS to make a complete review of the environmental impact
   a. assign an EIS adequacy rating of 1
   b. assess the environmental impact
   c. assign the appropriate environmental-impact rating (LO, ER, or EU)

2. If some information is available, but it is insufficient to review all impacts associated with the project
   a. assign an EIS adequacy rating of 2
   b. assess the impact presented in the EIS
   c. if possible, identify and estimate the magnitude of the impacts not presented
   d. based on b and c, assign an environmental rating to the project, and request necessary additional information and/or analyses

Preceding page blank

3. If insufficient information is available for even a partial review of the project impacts, an EIS adequacy rating of 3 should be given. In this case, no assessment or environmental impact rating should be made; instead, a completely revised EIS should be requested.

To insure that all significant primary impacts have been considered and that the assessments of the various types of impacts can be combined into a single assessment of the project, a systematic review procedure is necessary. Since the CEQ guidelines have defined major analysis categories to be included in EIS's, the review procedures are structured along the same lines.

Figure 1 illustrates the review sequence followed in these guidelines. The detailed review procedures for each category are given in the sections indicated. Since these guidelines are for the *review* of EIS's, the sequence in which the six CEQ categories are considered has been changed. The basic idea is to determine the unavoidable adverse impacts for the proposed project and for the alternatives to the proposed project. Then, a project assessment can be made in terms of the following: First, are the adverse impacts of the proposed project within acceptable limits? Second, can the impact be minimized by an alternative? Each review category fits within this framework as follows:

Project description. Review the basic description of the proposed action, placing in context the purpose of the project, the project's relationship to the surrounding area, and the project's relationship to other programs that might be affected.

Probable impact of the proposed project. Assess the project impacts and/or EIS adequacy with respect to the impacts related to air, water, noise, and solid waste management.

Relationship between local short-term uses of study area and the long-term productivity of the proposed project. Identify and assess those impacts which might have cumulative or long-term effects on the environment. Nonpollutant impacts, if applicable, should be considered here and in the next category.

Irreversible and irretrievable commitments of resources to the proposed project. Identify and assess those impacts which might irreversibly curtail natural resource utilization or the diversity and range of beneficial uses of the environment.

Probable adverse impacts that cannot be avoided. Summarize the assessment of those adverse impacts which cannot be avoided. After all alternatives have been considered, make final assessment of proposed project and relate to 1640.1 rating scheme.

Alternatives to proposed action. Repeat the review sequence, assessing the impacts from those alternative actions that might avoid some or all of the adverse impacts identified with the proposed project.

This review sequence should (including the 1640.1 rating scheme) be used by the air, water, noise, and solid waste management technical reviewers, as well as by the EIS coordinator. This procedure will aid the EIS coordinator in his task of combining the various assessments into a total project assessment-rating response.

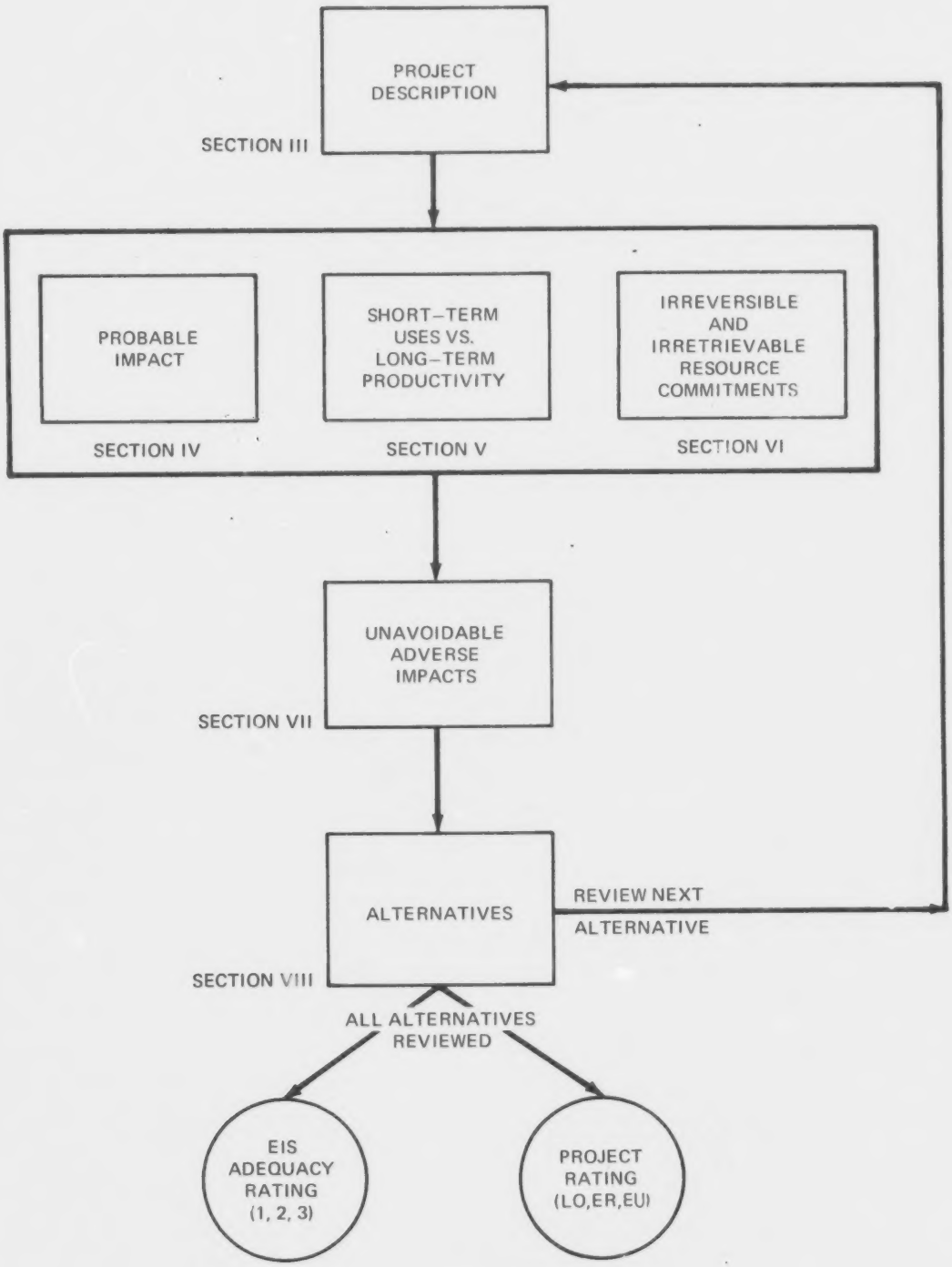

Figure 1.–EIS review process.

III. PROJECT DESCRIPTION

According to the Council on Environmental Quality guidelines, "the amount of detail provided . . . [in the description of the proposed action] should be commensurate with the extent and expected impact of the action, and with the amount of information required at the particular level of decision making. . . ." To insure that the review is consistent with this philosophy, the specific data-and-analysis requirements are combined with the impact assessment procedures given in the sections that follow.

Because the "particular level of decision making" relative to highway-project environmental impact statements (EIS's) is the location stage of development, the amount of information available at the location stage is of interest. To indicate the data that should be available for incorporation into the EIS, the following route location planning description is reproduced from the Highway Research Board's document, "Data Requirements for Metropolitan Transportation Planning."[7] *

> The initial inputs to the route location planning process are systems planning considerations and mainline design-hour volume (DHV) traffic factors developed from both system annual average daily traffic (AADT) forecasts and traffic count and inventory records. When related to design criteria, these determine the functional type of facility to be built—generally, whether or not access control is required. This may be a policy decision, however, and not necessarily a decision obtained directly from analysis of the input data.
>
> Next, the number of through lanes is determined, generally following American Association of State Highway Officials (AASHO) methodology. This involves selection of a K factor (deciding whether to satisfy traffic demand at the 30th, 50th, or some other specified "highest" hour); selection of a D factor, or proportion of traffic in each direction; and selection of a T factor, or proportion of heavy commercial vehicles. An additional input required for this decision is the set of design warrants that relate the number of lanes to volume and character of demand for each type of facility at each level of service.
>
> Several alternate route locations are then determined. Additional sets of data for this task are measures of physical, social, economic, and environmental influences in the corridor. Much criticized in recent years because physical and economic considerations have been the prime determinants of final locations, this task now gives social and environmental factors a considerable amount of importance.
>
> The final major decision involves choosing basic interchange decisions for each location. This requires additional input of local and cross traffic data in the corridor, and the use of interchange design techniques that relate interchange and ramp capacities to the volume and character of the traffic making the several turning movements.

*Other basic references for design criteria include the "Highway Capacity Manual"[8] and the American Association of State Highway Officials "policy" publications.[9,10]

Preceding page blank

In general, then, rather comprehensive descriptions of the project and its associated traffic projections are available for inclusion in highway project EIS's. The level of review presented in these guidelines assumes that these data are available.

Before proceeding with the review of the specific pollutant impacts, the reviewer should place the project in context with respect to the purpose of the project, the area through which the project will pass, and the relationship between the proposed project and other projects. This effort should aid the reviewer in defining the general level of review that will be required. To gain insight into a project, the reviewer may need to develop information from outside sources. Usually, investigation of the history of the project development (previous attempts and why they were not successful, legislative background, etc.) and discussions with local groups who may have personal knowledge of the project characteristics can provide useful additional information and understanding of the project.

IV. PROBABLE IMPACT OF THE PROPOSED PROJECT

Determination of the probable impact of the proposed project is the central effort of the review process. The results obtained here are key inputs to the final assessment of the project.

In what follows, the review-assessment procedures for impacts related to air (sec. IV.A), water (sec. IV.B), noise (sec. IV.C), and solid waste management (sec. IV.D) are described in detail. In general the review procedures are given in terms of

- Description of the impacts expected
- Review of the analyses needed to forecast the pollutant impacts
- Assessment of the impact

Where applicable (and possible), impact forecast procedures are included for use by the reviewer. These forecast procedures are of primary importance when reviewing an inadequate environmental impact statement (EIS). For such cases, an estimate of the project impact should be made and used as the basis for the project rating and to substantiate requests for additional analyses.

IV.A. AIR IMPACT REVIEW

Pursuant to Section 110 of the Clean Air Act and 40 CFR Part 51, State implementation plans (SIP's) are required to provide for the implementation, maintenance, and enforcement of the national ambient air quality standards within each air quality control region. To achieve the standards for carbon monoxide and photochemical oxidants, detailed transportation control plans were required in 18 of these plans (see app. A).

Within this framework, the reviewer must determine whether the project is consistent with the applicable SIP (or SIP's if an interstate project) or, in the absence of transportation-related controls, whether the project-induced emission pattern changes will interfere with attainment or maintenance of the national ambient air quality standards.

In either case, review of the air quality impact of a highway project will involve comparisons between the air quality projections assuming no project, air quality projections assuming the completed project, and the air quality standards. The impact assessment then is based on the significance of the differences between these air quality levels. Depending on the complexity of the project/project-area combination, these assessments may be required at both the microscale and mesoscale levels. In general, the microscale area is limited to that area near the roadway which is affected directly by the roadway. The mesoscale area, utilized for analyses in metropolitan areas, covers the larger area that could be affected by the project, either directly by pollutants emitted from the roadway or indirectly through the project's influence on overall traffic patterns.

IV.A.1. Highway-Related Air Pollutants

Table 1 lists those highway-related air pollutants for which national ambient air quality standards are in effect (40 CFR Part 50).

Of the pollutants listed, the photochemical oxidants are unique in that they are not emitted directly by sources. Instead, photochemical oxidants (and other products) are formed through the interaction of certain hydrocarbons and oxides of nitrogen in the presence of ultraviolet light. It also should be noted that the criteria for hydrocarbons rest almost entirely on their role as precursors of the compounds formed in the atmospheric photochemical system and not on the direct effect of hydrocarbons themselves.

Further, it should be noted that, in practice, NO_x (including both NO and NO_2) is often used as a measure of the total NO_2 concentration produced by automobiles. This usage results from the fact that, although a relatively small amount of NO_2 is emitted from automobiles, the NO emitted subsequently is oxidized in the atmosphere to form NO_2.

Since these "reactive" pollutants develop some time after they are emitted, the assessment of their impacts generally is limited to the mesoscale analysis.

An obvious limitation on the type of air pollution analysis possible is the availability of methodologies to complete the analysis. Because accurate quantification techniques are

Table 1.—Highway-related national ambient air quality standards

Particulate matter	Primary standard: 75 $\mu g/m^3$ annual geometric mean. 260 $\mu g/m^3$ maximum 24-hour concentration not to be exceeded more than once a year. Secondary standard: 60 $\mu g/m^3$ annual geometric mean. 150 $\mu g/m^3$ as a maximum 24-hour concentration not to be exceeded more than once a year.
Carbon monoxide	10 mg/m^3 (9 ppm) as a maximum, 8-hour concentration not to be exceeded more than once a year. 40 mg/m^3 (35 ppm) as a maximum 1-hour concentration not to be exceeded more than once a year.
Photochemical oxidants	160 $\mu g/m^3$ (0.08 ppm) as a maximum 1-hour concentration not to be exceeded more than once a year.
Hydrocarbons	160 $\mu g/m^3$ (0.24 ppm) as a maximum 3-hour concentration (6-9 a.m.) not to be exceeded more than once a year.
Nitrogen dioxide	100 $\mu g/m^3$ (0.05 ppm) annual arithmetic mean.

not yet fully developed, the types of analyses that can be performed are limited. The limitations involve both the scale on which the pollutants are considered and the analysis techniques that can be used.

Of the pollutants listed in table 1, only CO and particulates, which are relatively inert, have been modeled with consistent accuracy. To model the chemically reactive pollutants, HC, NO_x, and photochemical oxidants, schemes involving complex chemical reaction formulations combined with diffusion models (to simulate the atmospheric processes) must be used. Although several of these models are in the advanced state of development, none have been verified adequately for general use. Until such models become available the impact from these pollutants must be determined from simplified techniques such as the rollback method suggested for use in the SIP's (app. I to 36 F.R. 22412).

In view of these limitations, a state-of-the-art air pollution analysis would include

- A microscale analysis for the CO (related to the 1-hour and 8-hour standards) and particulate (related to the 24-hour primary standard) impacts
- A mesoscale analysis of the CO (8-hour), HC, and NO_x impacts.

IV.A.2. Review of Air Impact Analysis

The review of the air analysis consists of

- Reviewing the validity and applicability of the analysis method (a reasonable first step, since the analysis method dictates the extent of the data base required)
- Reviewing the analysis data and assumptions with respect to their validity and representativeness of the most adverse (i.e., "worst") conditions
- Estimating the impact for potential adverse situations not covered in the EIS

The reviewer should use these impact estimates to support requests for additional information in the final EIS.

Figure 2 illustrates the review sequence. Each of the boxed items is described in this section. The circled items are described in the impact assessment section (IV.A.3).

The reviewer should note that the following data descriptions relate to the detailed review of the air impact analysis, not necessarily to the EIS contents. The EIS contents should be considered adequate if the basic data and analysis procedures are at least summarized, *provided* the detailed procedures are available in referenced documents (see sec. II).

Analysis Methods.—The analysis method is defined as the computational scheme that operates on emission and emission-dispersion information to produce air pollutant concentration estimates. Although there are a variety of air quality estimation techniques available,[11,12,13] they can be categorized, in general, as atmospheric diffusion models, empirical models, or comparison techniques. In any case, the validity of method depends on its ability to represent accurately the transport and diffusion effects on the dispersion of the pollutant emissions.

Diffusion models. Of the three categories, diffusion models have been the most widely used and are considered superior for estimating CO pollutant concentrations* for a variety of conditions (provided that they are calibrated properly). These models are based on solving a diffusion equation that describes the flow of emitted pollutants through the atmosphere. There are currently two types of operational line source diffusion models: the Gaussion models, which are based on an analytic solution to the diffusion equation, and the grid models, which require numerical solutions of the diffusion equation.

Recent extensions have been made to the Gaussian formulation[14,15,16] that allow its application to a variety of highway situations. The work done by Beaton et al.,[16] of the California Division of Highways, is of particular interest for microscale applications. Under the auspices of the Federal Highway Administration (FHWA), Beaton's group has developed

*At present there are no available diffusion models for the reactive pollutants NO_x, HC, and photochemical oxidants.

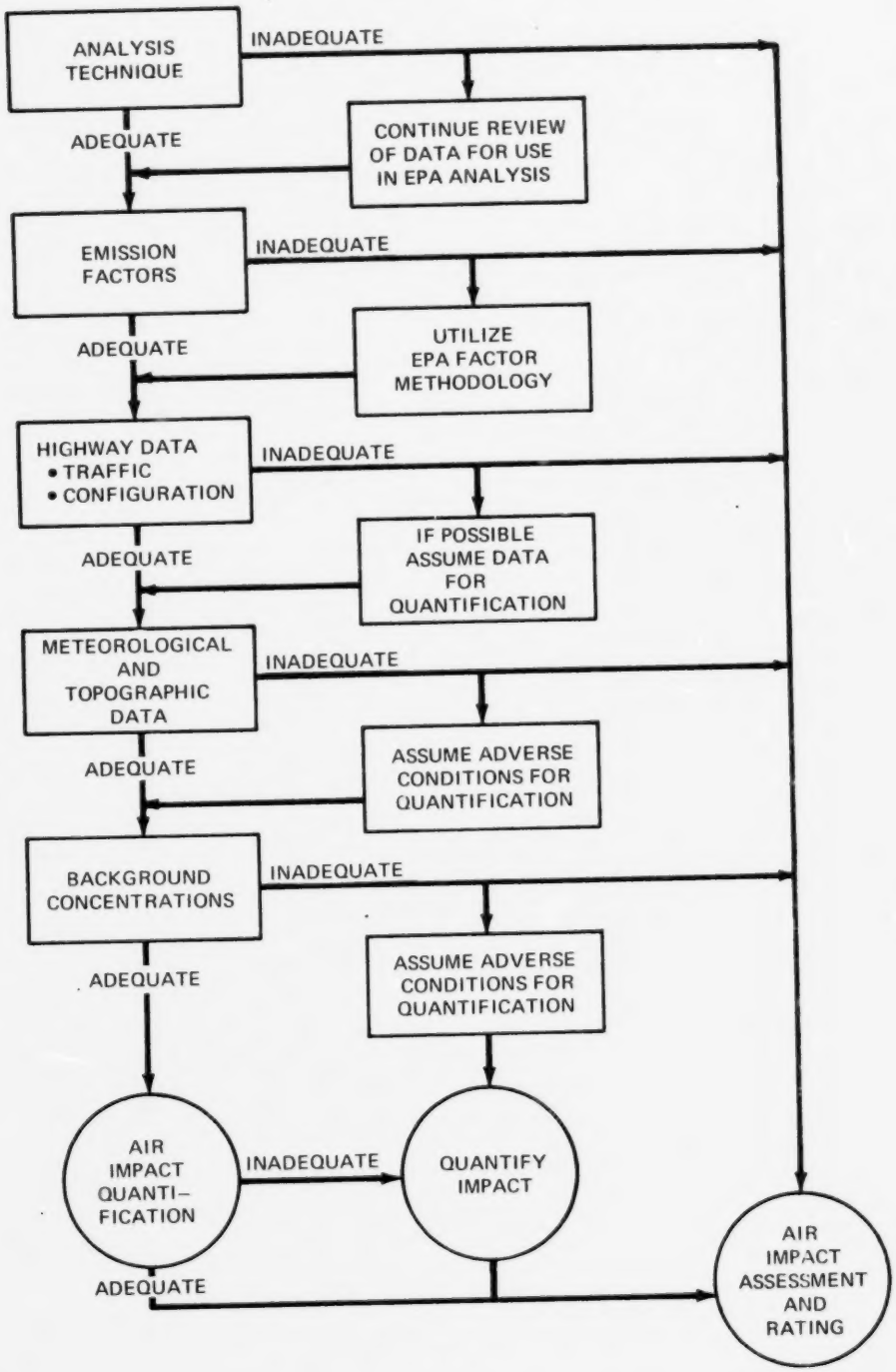

Figure 2.—Air analysis review sequence.

a specific methodology for the air quality analysis of highway projects. In addition to the development of a Gaussian model formulation,[16] the group's analysis methodology includes techniques for development of data that define the meteorology,[17] emission factors,[18] traffic information,[19] and ambient air quality sampling.[20] The documents cited have been distributed widely by FHWA, and the reviewer may expect to see these analysis techniques used in future EIS's. In general the techniques described in these documents, if modified for non-California applications, will produce results within the state-of-the-art error range.

For applications at the mesoscale level, the Gaussian models usually are converted to "area source" models, which allow consideration of a number of roadway segments with each calculation (e.g., APRAC-1A).[21] Such models are generally computer dependent, since a large number of calculations are involved.

Grid models applicable to highway air-pollution analyses have been reported in the literature by Danard[22] and Skalarew et al.[23] Although these models are at an earlier stage of development than the Gaussian models, they do have the potential for a more accurate representation of the parameters influencing the dispersion process.

In addition to the federally sponsored models, there are at least a dozen commercial models in use. The reviewer must determine that an acceptable model has been used for the EIS analysis. If this determination presents a problem, personnel at the Division of Meteorology, Office of Research and Development, Research Triangle Park, North Carolina, should be consulted.

A discussion of procedures for quantification of the microscale CO impact is given in appendix B.

Empirical models. The objective of these models is to infer, from measured data, the parametric dependencies that relate the pollutant concentrations to the emission and transport characteristics. This method, properly carried out, can produce valid estimates for specific situations. It is generally the case, however, that an insufficient range of traffic conditions and meteorological parameters are obtained to make such models truly representative, and if they are used their results should be checked carefully (see app. B).

Comparison technique. The comparison technique simply assumes that similar projects will have similar air quality impacts. This technique is the least reliable of the three. If it is used the reviewer must determine that a true parallel has been made between the comparison project and the proposed project. Significant similar conditions that must be related are

- Meteorological conditions: If both projects are in the same general area, the assumption of similar meteorological condition is usually valid (provided that the areas are similar in topography).

- Topography: Significant differences could cause local stagnation conditions to be overlooked.

a specific methodology for the air quality analysis of highway projects. In addition to the development of a Gaussian model formulation,[16] the group's analysis methodology includes techniques for development of data that define the meteorology,[17] emission factors,[18] traffic information,[19] and ambient air quality sampling.[20] The documents cited have been distributed widely by FHWA, and the reviewer may expect to see these analysis techniques used in future EIS's. In general the techniques described in these documents, if modified for non-California applications, will produce results within the state-of-the-art error range.

For applications at the mesoscale level, the Gaussian models usually are converted to "area source" models, which allow consideration of a number of roadway segments with each calculation (e.g., APRAC-1A).[21] Such models are generally computer dependent, since a large number of calculations are involved.

Grid models applicable to highway air-pollution analyses have been reported in the literature by Danard[22] and Skalarew et al.[23] Although these models are at an earlier stage of development than the Gaussian models, they do have the potential for a more accurate representation of the parameters influencing the dispersion process.

In addition to the federally sponsored models, there are at least a dozen commercial models in use. The reviewer must determine that an acceptable model has been used for the EIS analysis. If this determination presents a problem, personnel at the Division of Meteorology, Office of Research and Development, Research Triangle Park, North Carolina, should be consulted.

A discussion of procedures for quantification of the microscale CO impact is given in appendix B.

Empirical models. The objective of these models is to infer, from measured data, the parametric dependencies that relate the pollutant concentrations to the emission and transport characteristics. This method, properly carried out, can produce valid estimates for specific situations. It is generally the case, however, that an insufficient range of traffic conditions and meteorological parameters are obtained to make such models truly representative, and if they are used their results should be checked carefully (see app. B).

Comparison technique. The comparison technique simply assumes that similar projects will have similar air quality impacts. This technique is the least reliable of the three. If it is used the reviewer must determine that a true parallel has been made between the comparison project and the proposed project. Significant similar conditions that must be related are

- Meteorological conditions: If both projects are in the same general area, the assumption of similar meteorological condition is usually valid (provided that the areas are similar in topography).

- Topography: Significant differences could cause local stagnation conditions to be overlooked.

- Traffic flow and mix: Usually some factor will be applied to scale these parameters. The reviewer should question the validity of the scaling method if major traffic differences are projected.

- Highway configuration: Different configurations between the projects (e.g., cut versus elevated) could cause pronounced differences at specific locations.

In the remaining analysis-review discussions it is assumed implicitly that a diffusion model will be used (at least for the microscale analysis). This assumption is made for several reasons. First, as discussed earlier, diffusion models are the most accurate of the techniques and should be used as the analysis method for most projects. Second, diffusion models require the most comprehensive set of input data. If a simpler *acceptable* technique is used its input data will be, in general, a subset of the data described.

Emission Factors.—The method for determining total motor vehicle emissions consists of multiplying the appropriate emission factors (representing on-the-road emission rates) by the vehicle-miles traveled. Table 2 summarizes the traffic parameters required for both the emission factor and emission rate determinations.

The EPA report, "An Interim Report on Motor Vehicle Emission Estimates,"[24] contains the methodology for determining CO, HC, and NO_x emission factors for light- and heavy-duty

Table 2.—Traffic parameters for emission estimates

Analysis level	Traffic parameters	Source of estimated emissions	
		With project	No project
Microscale	Peak-hour volume Average speed for peak-hour travel Emission factor data: Region Vehicle type Age distribution Annual travel	Project traffic Surface traffic (excluding project) Major point sources	Surface traffic Major point sources
Mesoscale	Average trip length Average trip speed Emission factor data: Vehicle type Age distribution Annual travel	Surface traffic (including project) Major point sources	Surface traffic Major point sources

gasoline-powered motor vehicles. Since this report is considered to represent the state of the art for emission factor determination, the review of emission rates used in the EIS analysis should be based on the EPA procedures. If an analysis uses emission factors other than the EPA report, the reviewer must determine their validity. In making this determination, it is advisable that the reviewer seek assistance from the National Air Data Branch, Office of Air Quality Planning and Standards.

Traffic Data.—Review of the basic traffic data (traffic volume and speed estimates) is probably the most difficult of the data reviews. These data, which result from a myriad of sampling and projection techniques, are related directly both to the justification of the project and to the pollution impact of the project. Without a sufficiently comprehensive set of traffic data, quantification of the air impact is difficult, if not impossible.*

For many projects the fundamental traffic volume data are estimates of annual average daily traffic (AADT), based on counts (made at intervals throughout the year) on the highway under consideration or on similar highways. In such cases empirical methods are used to adjust the AADT data to design hour volumes. Since these techniques also produce, or may be used to produce, peak-hour volumes for the design of individual roadways (which also influence the speed estimates), it is important that the methodology used and its limitations be described fully in the EIS.

The average trip speed utilized in the emission factor determination represents the time period of interest (e.g., time period of standard). For a microscale diffusion model analysis, the vehicle speed must reflect the average operating speed, over the time period of interest, for the particular lane under consideration (or lanes if the total roadway is considered as a single line source).

In general, the reviewer should determine that the traffic volume and speed estimates

- Are compatible with estimates presented in existing plans (land use, transportation, SIP, etc.)
- Are documented with respect to methodology used to determine them
- Include appropriate recognition of the various types of "generated" traffic that might occur
- Are compatible with the level of service of the proposed roadway

Highway Configuration.—The highway configuration includes the alinement interchange locations, type and location of section changes, and highway dimensions. These parameters influence the air quality impact by defining the highway's proximity to receptors and by influencing the pollutant dispersion characteristics.

*See appendix C for a general discussion of traffic data characteristics.

Alinement. For modeling purposes, the alinement of the roadway is defined by the location of the right-of-way lines. Its precise location is used in relating the roadway to receptors, local topographic problem areas, and relative wind directions.

Interchange locations. Since interchanges are points of traffic exchange between the project and other roadways, these locations should be examined in detail with respect to the receptors affected, traffic changes predicted between the with-project and no-project situations, and meteorological perturbations due to interchange configuration. If there are receptors at these locations, the CO contribution from both the project and the interchange roadway should be modeled.

Section identification. The most common types of highway sections are at grade, depressed, fill, and elevated. These section types can be handled fairly well by existing models. For tunnels, cantilevered covering, intermittently covered sections, etc., diffusion model techniques are not well defined. In general, these section types tend to confine the pollutants, especially for the worst meteorological conditions of low wind speeds and low-level inversions. Elevated sections have much the same pollutant distribution characteristics as elevated point sources; that is, the maximum ground-level concentrations will occur at some distance from the source. Barring unique meteorological conditions, the elevated section is the only type that can produce a maximum concentration point beyond the highway right-of-way line.

Highway dimensions. For modeling purposes, specific dimensions of the roadway are required to define precisely the "downwind distance." These data include:

- Number and width of lanes: For multilane roadways with narrow rights-of-way, each lane probably should be treated as a separate source.

- Width of separator: For divided roadways, each flow direction usually will be treated as a separate source (as a result of the different traffic flow characteristics). If the separator is sufficiently wide, the upwind lanes may be treated as a single line source.

- Distance from roadway edge to right-of-way line: The reviewer should note wehther this distance is sufficient to accommodate an additional lane. If so, the possibility of future lane additions should be considered.

Meteorology.—The meteorological parameters of prime importance to modeling efforts are the wind speed, wind direction, atmospheric stability, and inversion (or mixing) height. For the microscale analysis the critical values for each of these parameters, over each season, must be estimated along the length of the project. In addition, these parameters should be determined for the time periods corresponding to the peak traffic volumes. These data, when modified for local highway configuration and topographic influence, must represent the "worst" set of meteorological parameters applicable to the various segments of the project. These worst cases are then combined with the traffic data along each segment to define the adverse cases for analysis.

For diffusion model applications the meteorological data take the form of mixing height and stability wind rose data. The mixing height is assumed to mean that a stable layer exists above this height. If the pollutant plume disperses sufficiently (as it progresses downwind) to be affected by the lid, the Gaussian distribution assumption must be modified.[11]

In general, only low inversion heights (less than 200 meters) will influence the microscale pollutant analysis procedure. For example, a typical highway-related plume would interact with a 200-meter inversion at about 400 meters from the source, which is well beyond the maximum concentration point in the microscale analysis.

A wind rose gives the frequency of occurrence for each wind direction (usually to 16 points) and wind-speed class (nine classes in Standard Weather Bureau use) for the period under consideration. A stability wind rose gives the same type of information for each stability class. The most critical daily periods for the construction of stability wind roses are usually the morning (0700 to 0900) and evening (1600 to 1800) rush hours. Depending on the specific situation, other periods may need to be examined.

Various Federal, State, and local organizations routinely collect and process meteorological data. The most notable of these is the National Climatic Center in Asheville, North Carolina. This center will prepare, on request, a summary of all pertinent data available for a given geographical area. In most cases, however, these data must be supplemented by meteorological surveys along the project route. The extent, duration, and data reduction techniques of such surveys should be reviewed with respect to their supportive role in the air quality analysis; that is,

- Have sufficient data been collected to define the worst conditions along the highway route?
- Has the survey covered time periods sufficient to determine the critical diurnal season?
- Are the data collection and reduction techniques adequate?

Topography.—Local topography can influence both the wind direction and the atmospheric dispersion characteristics. Unless the meteorological parameters have been obtained at each site application, these data should be adjusted to reflect at least the major topographic influences, including

- General wind flow around buildings, hills, and mountains
- Channeling effects of winds in canyons and valleys
- Areas of drainage winds
- Areas where surface inversions may exist due to cool-air drainage

- Areas of limited dispersion due to valley walls

- Wind flow alterations around different types of highway sections (cut, fill, viaduct, etc.)

Proper adjustment of the meteorological parameters to account for topographic effects can be extremely tricky and should be done by a meteorologist familiar with diffusion model applications.

Background Concentration.—Since it is the *total* pollutant concentration values that must be compared to the standards, the pollutant contributions from the nonproject sources must be included in the analysis. In general, the background concentration is defined as the pollutant concentration level that, when added to the contribution from the project itself and specific local contributions from other major sources, will give the total pollutant concentration level.

For the most part, the background pollutant contribution comes from the mesoscale sources, and can be obtained: through utilization of mesoscale diffusion models (for CO), by the "rollback" technique (for all pollutants), or by using preproject ambient air quality levels (corrected for major growth areas). The rollback technique, which has been used by most States in their SIP's, is described in "Requirements for Preparation, Adoption, and Submittal of Implementation Plans."[25] In any case, the background projections should be checked against any applicable SIP projections.

Unless an extensive air quality monitoring network is in existence (as demonstrated in the SIP), specific monitoring activities usually must be implemented along the project route. These data are required to establish the existing ambient air quality levels. In addition, by using the relationship between the existing traffic information and a comprehensive set of existing air quality levels, the rollback technique (or modeling, if done) will provide more accurate estimates of the pollutant concentrations expected from the projected traffic levels. This is especially true for major projects or in areas with complex topographic characteristics.

In general, additional air quality surveys must be taken if local meteorological and source characteristics, topography, or degree of urbanization at specific points along the project differ significantly from conditions where the existing air quality monitoring stations are located. Sensitive points that may require additional monitoring can be identified by existing pollutant levels, a high or potentially high degree of urbanization within the design life of the roadway, topography or meteorology conducive to pollutant trapping, those sections of roadway prone to congestion within the design life of the road, or the proximity now or in the future of sensitive receptors.

IV.A.3. Assessment of Air Impact

In conjunction with the air quality assessment, the reviewer must determine that the analysis includes identification and quantification of all significant impact areas. Because the impact from a highway is a function of both the type of highway and the area through which

it passes, an initial estimate of the level of analysis required should be made. As a guide, table 3 defines three levels of analyses that can provide adequate estimates of the primary air quality impacts from a variety of highway-type project-area combinations. Project areas are broadly categorized as rural, urban, and metropolitan. The specific points of transition between these categories will depend on the project under consideration and must be determined by the reviewer.

The review and assessment procedures for each of the review levels are described in succeeding paragraphs. Since these procedures apply to projects ranging from new freeway construction in urban areas to highway modification in isolated areas, they are necessarily generalized. It is important that the reviewer recognize the generalizations in these procedures and that he be prepared to make adjustments to accommodate any exceptional circumstances of a given project.

Review Level 1: Construction Impact.–Direct assessment of the air quality impact from construction activities is difficult, owing to the lack of appropriate emission factors. As a result, this review is based on insuring that "reasonable" precautions have been planned to minimize the impact. Of the possible air pollutants, only particulates in the form of fugitive dust are generally a problem.* Reasonable precautions that can be used to minimize the fugitive dust impact include

- Spatial and temporal distribution of cut-and-fill operations to minimize emission concentrations
- Liquid dampening of excavation areas to reduce level of emissions (note that adverse water impacts must be avoided, see sec. IV.B).
- Construction curtailment during times of limited dispersion conditions

In order to determine if proper emphasis has been placed on the construction impact abatement methods, the reviewer should estimate the "potential" impact at selected sensitive receptors. This potential can be quantified in terms of the percent of the generated pollutants that would reach the receptor under the most adverse meteorological conditions (during construction periods). This estimate combined with an estimate of the magnitude of the project emissions should serve as an impact indicator. For example, a situation in which a residential area would receive a significant portion of the emissions generated during a major cut operation would warrant special abatement considerations.

Unless the reviewer can pinpoint a major impact, this review is not critical to the overall air quality rating of the project. The reviewer should, however, note those areas which may be a problem and, if possible, suggest appropriate abatement action that could be taken.

Review Level 2: Microscale CO Concentrations.–The CO review, including both 1- and 8-hour averages, should be carried out for all new major highways, regardless of population

*Impacts from open burning of spoil are discussed in section IV.D.

Table 3.—Level of analyses adequate for estimating the air quality impacts from highway projects

Type of project	Project area							
	Rural with no population in microscale area		Rural with increasing population in microscale area		Urban		Metropolitan*	
	Microscale area	Mesoscale area	Microscale area	Mesoscale area	Microscale area	Mesoscale area	Microscale area	Mesoscale area
Highway modification that does not increase capacity	None	None	None	None	Level 1, construction impact	None	Level 1, construction impact	None
New minor highway or modification that increases capacity	None	None	Level 2, maximum CO	None	Levels 1 and 2, construction impact and maximum CO	None	Levels 1 and 2, construction impact and maximum CO	None
New major highway	Level 2, maximum CO	None	Level 2, maximum CO	None	Levels 1 and 2, construction impact and maximum CO	None	Levels 1 and 2, construction impact and maximum CO	Level 3, maximum CO (8 hr), HC (3 hr), NO_x (annual)

*This category includes at least the 26 regions with transportation plans (see app. A).

Reproduced from best available copy.

density, and for new minor highways or highway modifications increasing capacity in areas already developed or for which development appears likely. The analysis of major highways in unpopulated areas (as shown in table 3) is needed owing to their unpredictable inducement of population growth. The air impact data in these areas can be an essential planning input for future development.

The objective of this review is to determine that the air quality impact, in the microscale area, has been identified and quantified properly for the entire project. A minimum analysis that will produce these results consists of

- Estimates of the magnitude and location of the maximum CO concentration values along the length of the project
- In those areas in which either of the CO standards is exceeded, the spatial location of where the CO standards are first exceeded
- CO concentration levels at sensitive receptors (schools, playgrounds, etc.) located near the project

In general, it is convenient to assess the impact by considering the highway project in terms of a series of contiguous "segments," along each of which a different set of conditions prevails (that is, the meteorological conditions, traffic parameters, highway configuration, and background concentrations). As a result, the maximum concentration contours should be a series of straight lines (with local modifications for major extraneous sources). The length of each segment for which common conditions may be assumed will vary depending on the detail of the data base. For example, if the project topography is uniform, the same meteorological conditions might be applied for a considerable length of the project. Obviously it must be left to the reviewer's discretion, based on his understanding of the factors involved, to determine the extent to which conditions may be assumed to be constant. It is emphasized that the *intent* is to insure that the complete project has been analyzed. That is to say that either each segment of the highway has been analyzed with respect to its specific CO impact or, by a comparative analysis of data bases, the concentration of a given segment has been shown to be less than the calculated concentration of a comparison segment. Again, it is left to the reviewer to judge the applicability and accuracy of this approach.

In performing the CO concentration review, the following guidelines should be observed:

1. Area of interest extends from the project right-of-way line into the microscale area. This limitation results from the special complications involved in applying line source models to determine onroad concentrations. In the general situation this restriction is not critical to the microscale impact assessment. With the exception of locations involving elevated highway sections or unusual topographic situations, the maximum CO concentration value in the "area of interest" will occur at the right-of-way line.

2. The CO concentration values along each segment should be based on the most adverse (i.e., resulting in the highest concentration values) set of meteorological and traffic conditions. In general the highest concentrations will result from using the most adverse meteorological

conditions that could be expected to occur during the peak traffic hours and the associated peak traffic data. The combination of these conditions is referred to as the "worst-worst" conditions. Since the meteorological conditions involve a number of parameters (wind speed and direction, atmospheric stability, mixing height, etc.), the selection of the most adverse combination requires careful review.

3. The background CO concentration should be included in the total CO concentration values presented. The background concentration, as used here, is the concentration resulting from (a) major sources near the project, and (b) all other contributing sources in the micro-scale and mesoscale areas. Although the background levels are difficult to obtain, estimates of their magnitude must be made; without these data the project impact cannot be related directly to the air quality standards.

4. CO concentrations should be estimated for that time period within the project life-time for which maximum emissions are expected. The project lifetime is considered to be the time period from the estimated time of completion (ETC) of the project through ETC + 20 years. Depending on the impact found for this critical period, concentration values for other time periods within the 20-year span may be required (thus estimates of the vehicle emission growth characteristics must be made). Vehicle emissions are the product of emission factors and vehicle population. Since the emission factors are decreasing with time (owing to increasing percentages of controlled vehicles) and vehicle population is increasing with time, the net change in emissions can either increase or decrease, depending on which parameter dominates. Figure 3 illustrates several emission growth possibilities. Although both the project emissions and the background emissions (reflecting the mesoscale traffic) may exhibit the same emission growth trends, their peaks may occur at different times; thus, the critical time period defined here should reflect the maximum of the total emissions.

5. CO concentrations for the no-project alternative should be determined. For the situations involving improvements to an existing roadway, the procedure is generally straightforward since the comparison points (right-of-way line, sensitive receptors, etc.) are existing for both situations. For new projects, comparison points must be selected. For this purpose it is most convenient to select those existing sensitive receptors, closest to the project right-of-way, which will remain undisturbed after the project is completed.

To determine if the impact has been quantified properly, or to estimate concentration values at potentially critical areas that were not included in the EIS, the reviewer can use the techniques described in appendix B.

Based on the results presented in the EIS or as estimated by the reviewer, one of the following situations will occur:

CO standards not exceeded. If the worst-worst case for the critical time period produces CO concentrations below the standards for all of the highway "segments," the project is satisfactory from an air quality standpoint (provided that review levels 1 and 3 are also satisfactory). Exceptions to this assessment may be made if the proposed project accounts for a significant long-term increase in CO concentration levels over the no-project alternative. Figure 4 illustrates such a situation for a given highway segment. Note that the level of

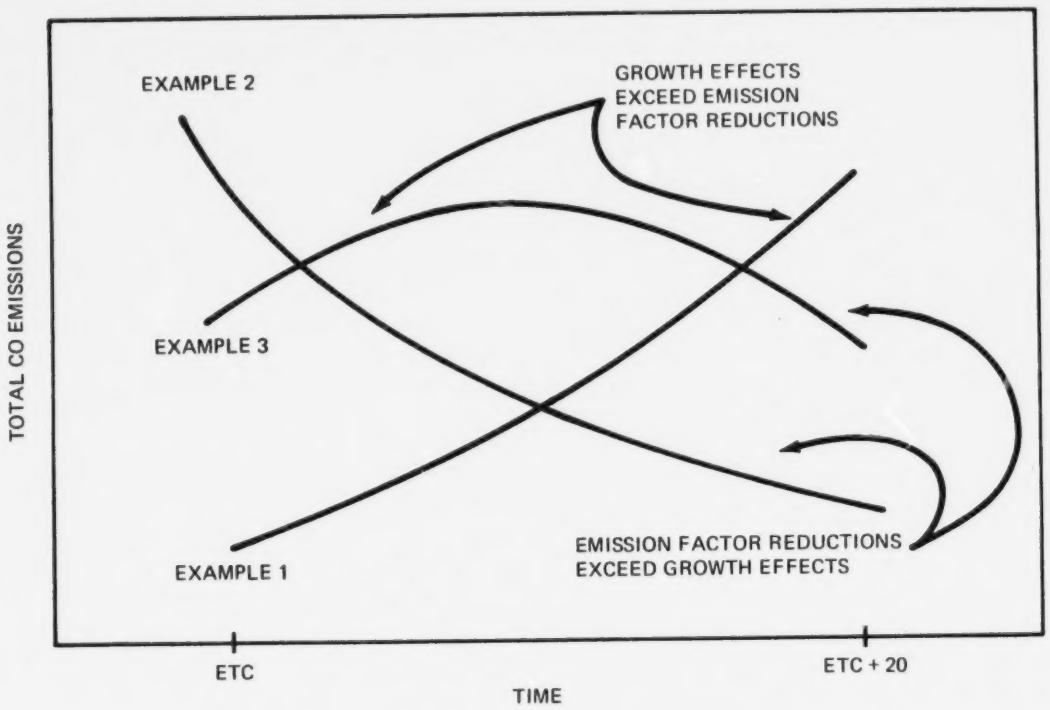

Figure 3.—Examples of emission growth trends.

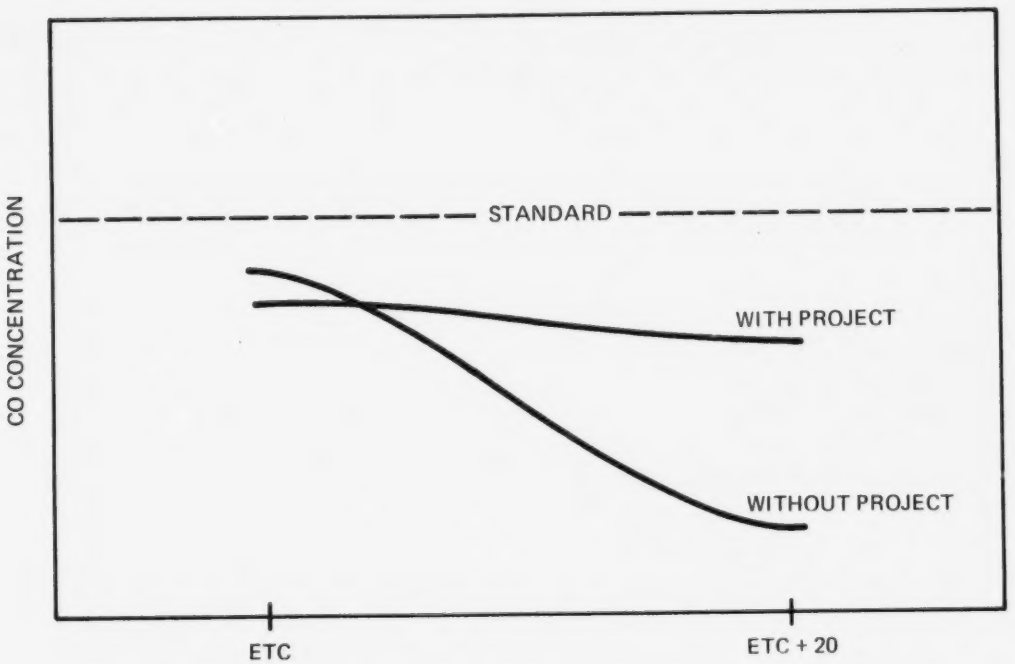

Figure 4.—Example CO concentration patterns for a given highway segment.

degradation is dependent on the shape and location of the no-project line. The overall microscale CO assessment would be based then on the number of questionable segments and the severity of their CO degradation.

CO standards exceeded. This case allows for the possibility that either the 1-hour or 8-hour CO standard may be exceeded for a few segments and/or over a limited time period. The primary concern is whether the project enhances the attainment and maintenance of the CO standards. For this second case, comparisons between the with- and without-project CO levels over time are required and should be the basis of the impact assessment.

Review Level 3: Mesoscale Analysis.—In essence this analysis is a Project-SIP consistency review, which is intended to reconcile the traffic generation and redistribution characteristics of highway projects with specific (if any) vehicle use reduction or traffic pattern control measures contained in the SIP. Of particular interest are those SIP's which include detailed transportation control plans (see app. A). These control plans (as specified in 40 CFR Part 5.1 and further described in 38 F.R. 1464, Jan. 12, 1973) consist of

- Identification of specific transportation control measures to be implemented (reducing vehicle use, changing traffic flow patterns, decreasing emissions from individual motor vehicles, etc.)

- A demonstration of the adequacy of these measures for attainment and maintenance of the national ambient air quality standards

- A detailed timetable for obtaining necessary legal authority and taking all other steps necessary to implement the various measures

The reviewer must determine if the proposed project is compatible with these plans.

The mesoscale air quality review is concerned with the 8-hour CO, 3-hour (6-9 a.m.) HC, and annual average NO_2 standards (the 1-hour CO review is described under "Review Level 2"). The analysis of these pollutant levels should be consistent with applicable SIP emission inventory and analysis techniques (i.e., diffusion modeling or rollback). The SIP pollutant estimates should be used as a base line from which the project-induced changes can be determined.

If the EIS does not contain a mesoscale analysis, the reviewer can make an order-of-magnitude impact assessment by utilizing a pollutant burden analysis that consists of the following elements:

1. From the SIP air quality projections, determine the time history of the CO, HC, and NO_x pollutant concentrations. Note that the analysis (mesoscale) area should be restricted to that area which could be influenced by the project. This restriction should be made to prevent inclusion of an area so large that the changes in total emissions will not reflect the project influence.

2. Compare the relative emission totals of the with-project and no-project situations over ETC + 20 years.* If possible, the pollutant trend and critical year between ETC and ETC + 20 years should be determined.

3. If the with-project emissions are always less, the project is satisfactory.

4. If the with-project emissions significantly exceed the no-project emissions during a time period in which the pollutant concentrations are critical (i.e., close to or exceeding standards), the project is unsatisfactory and a detailed analysis should be requested.

5. If the with-project emissions exceed the no-project emissions during noncritical periods, the project approval will depend on the total degradation involved. A detailed analysis should be requested.

*If the SIP data are for less than a 20-year period, the projection should be extrapolated.

IV.B. WATER IMPACT REVIEW

In reviewing the water quality aspects of highway-project EIS's, particular emphasis should be placed on the project's ability to conform to the Federal Water Pollution Control Act Amendments of 1972. In particular, sections 208(b), 303(c), and 304(e) relate to water quality impacts associated with the construction and operation of highway projects. The reviewer also should be familiar with the following sections of the act, which provide for non-EIS-related assessment activities within EPA:

Section 103(b)–Demonstration grants
Section 105(d)–Practical application of waste management techniques to point and nonpoint sources
Section 305(b)–State annual report to EPA section on non-point-source control
Section 311 (b, c, f, j)–Oil and hazardous materials control
Section 404 (b, c)–Discharge of dredged or fill material into navigable waters

In addition, the reviewer should be cognizant of EPA policies presented in the Administration's decision statement No. 4, "EPA Policy to Protect the Nation's Wetlands," February 21, 1973.

The reviewer also should utilize related agency outputs and programs to insure a comprehensive EIS review. Particular attention should be focused at coordinating the EPA positions taken on projects requiring Corps of Engineers' permits (either at the public notice review stage or at the EIS review stage).

IV.B.1. Highway-Related Water Impacts

The water problems associated with a particular highway project will involve one or some combination of the following:

- Turbidity of watercourses due to erosion
- Watershed modification
- Highway runoff contamination
- Sanitary wastes from temporary and permanent waste disposal facilities
- Contamination of surface and ground water supplies and recharge areas by polluted fill material

The reviewer must determine that these issues have been developed adequately in the EIS. Although some of these water problem areas may be less significant than others, the reviewer should identify and assess all problem areas and, if possible, suggest alternative abatement procedures.

IV.B.2. Review of Water Impact Analysis

Before the assessment of the water impact, the reviewer must be able to ascertain the relationship between the project and its surrounding area as well as the sensitivity of the surrounding area. The essential elements in this review consist of identifying

- The type of area traversed by the project
- The project drainage system
- The receiving water system

In each case the reviewer must be able to relate the descriptions to the five water problem areas identified in section IV.B.1.

Project Area Description.—The project area must be identified fully and described in such manner that the potential impact areas are identified completely (e.g., areas requiring continuous fills, rerouting of streams, ground water interception).

The description should include any applicable land use or transportation plans (ongoing or in preparation). Such plans not only provide additional descriptions of the project area, but also provide a framework within which the project must exist. If such formal plans do not exist it must be determined whether any local, State, or Federal projects will influence or be influenced by the project under consideration.

In any case, the level of detail for the area description should be consistent with the nature of the area. For instance, if segments of the project cross sensitive areas, such as estuaries, marshes, or wooded swamps, detailed descriptions of these areas must be included.

Drainage Pattern Description.—The EIS must describe the natural drainage system, the temporary construction drainage system, and the postconstruction drainage system.* The statement also should detail the permanent changes and describe how the temporary drainage system will provide a minimum impact transition from the natural system to the postconstruction system. The project drainage area generally will involve land areas outside the project right-of-way that must be considered for potential runoff. The extent of disruption and pollution of this runoff should be assessed by the State highway authority, and a plan for control should be set forth. As a minimum, this plan must include a contingency plan for dealing with unanticipated water quality deterioration that can be activated by the onsite construction manager. If appropriate, the reviewer should suggest that the plan be enlarged to describe and schedule sediment control actions.

There also should be a general discussion of changes in drainage patterns caused by initial or concurrent demolition of older highways in the project area. Often the contingency and final plans for environmental protection on highway projects are not written to

*See "Guidelines for Hydrology, Vol. II"[26] for a discussion and bibliography on highway drainage facilities.

cover demolition and preconstruction clearing (or, if written, the plans are ignored in the haste to clear and begin new construction). These considerations are especially important when the project lies within the flood plain of a watercourse.

Receiving Waters Description.—The EIS must provide complete information on the affected water system, including data on quantity and quality, as it relates to the five highway water problem areas. A listing of important bodies of water and critical stream reaches where water quality is already low should be included. The applicable Federal-State water quality standards, especially with regard to turbidity, should also be referenced and summarized in the statement. The statement should explain how compliance with applicable standards will be insured.

There are several planning and information dissemination provisions in the Federal Water Pollution Control Act (secs. 303(e), 304(e), and 208(b)) that may be used to provide detailed information on the receiving water system. Although the State planning documents filed under section 303(e) requirements are not due until July 1974, useful preliminary information should be available immediately.

Non-point-source pollution, particularly that pollution resulting from construction activity, is mentioned specifically in sections 208(b) and 304(e) of the act. Since non-point-source control is predominantly a State- and local-government problem, the reviewer should look for discussions in the draft statement that recognize this responsibility. All appropriate local controls, such as pollution control ordinances, subdivision ordinances, and zoning ordinances, should be discussed and must be complied with. If local legal controls for prevention of non-point-source pollution do not exist, the statement should describe the procedures that will be utilized to restrict poor nonpoint practices by private contractors.

IV.B.3. Assessment of Water Impact

Assessment of the five highway-related impact areas involves relating the identified impacts to specific criteria governing acceptable levels of degradation. While a quantitative method for arriving at a final assessment (i.e., rating) is not proposed here, it is recommended that the reviewer assess the proposed highway project by analyzing the five water impact areas with respect to: probable violations of applicable Federal, State, and local water-related standards; inconsistencies with Federal, State, or local regulations and plans; and any significant degradation of water quality or water-related activities.

Sediment.—Turbidity and silting of adjacent streams and reservoirs are caused, for the most part, by the erosion of the raw soils exposed during construction and maintenance operations. The primary impact of these effects generally will involve one or more of the following:

- Increased operating costs or shortened life of affected reservoirs and channels
- Damage or elimination of fish and other aquatic life
- Possible damage to buildings, roads, and bridge foundations

Soil erosion abatement or compensatory measures are described in publications available from EPA,[27,28] the Department of Transportation (DOT),[29,30] and the Soil Conservation Service.[31] Also, State highway departments often have publications containing sediment control programs and criteria. The reviewer should be familiar with all of these publications. The EPA publications, "Control of Erosion and Sediment Deposition from Construction of Highways and Land Development"[27] and "Guidelines for Erosion and Sediment Control Planning and Implementation,"[28] should be used as primary reference documents when reviewing a statement for its treatment of the sediment control subject.

In particular, the reviewer should insure that all appropriate abatement measures have been utilized to minimize erosion of exposed areas. Common abatement measures include

- Construction scheduling such that the total exposed area is minimized over time
- Timely application of seed, mulch, fertilizer, lime, sod or other vegetative cover
- Use of diversion or intercepting ditches, riprap, concrete lining, retention basins, etc.
- Combining borrow and fill areas (depending on construction scheduling) and/or diking these areas to prevent silting of adjacent watercourses

In any case, borrow and fill areas should be located to minimize damage to wildlife and marine ecosystems.

In the future, sections 208(b) and 303(e) of the Federal Water Pollution Control Act will provide additional material defining the requirements for sediment control. Section 208(b) areawide plans will include procedures and methods to control sources of pollution related to construction activity. These plans mainly will cover metropolitan areas.

The State planning process, under section 303(e), requires States to provide evaluation of the non-point-source impact on water quality.* As these plans become operational (in July 1973), regional reviewers can use the guidance available in 40 CFR 131.211 (July 9, 1973).

Watershed Modification.—Serious water quality problems can be caused by the impingement of the road system and its construction on estuarine areas, marshes, wooded swamps, and streams. The reviewer should pay particular attention to the impacts from drainage systems, borrow and fill operations, and sedimentation basins and lagoons. The borrow and fill operations should be consistent with the sediment control requirements described previously.

Frequent and proper drainage should be provided by use of bridges and pile support over valuable marsh areas, and of sufficient culverts in other fill areas so that drainage or tidal flushing is not impeded. Improperly drained areas can trap water, thus increasing unnatural evaporation. Such areas, if sufficiently large, also can become anaerobic and

*See EPA interim regulations, "State Continuing Planning Process," 38 F.R. 8034, Mar. 27, 1973.

threaten public health. In marshlands, improperly drained highways also can reduce tidal flushing. This condition may interrupt extremely delicate and important ecological processes within the marsh. Further, drainage of marshlands can increase total runoff causing higher flood flows in the streams. This effect results from lowering the water table, which increases soil evaporation and changes the type of vegetation and elimination of the marshland as a natural flood control reservoir.

In general, a route with a ditch system that intercepts, diverts, and conveys the least amount of water will have the minimum water quality problems. A route that follows high ground or ridges generally will intercept the least amount of water. Road ditches generally speed up runoff from a drainage area by conveying water quickly to stream beds.

It is important that the flow of waters in estuarine areas be maintained similar to their natural flows. Disturbance of natural flows can affect ecological determinants, such as sedimentation patterns, mixing of fresh and salt waters, nutrient flows, shellfish beds, fish and wildlife, and local vegetative patterns. A decrease in water level caused by diminished flows can alter nearby vegetation significantly. Migration patterns of indigenous species (such as anadromous fish) should be determined in order to ascertain whether the highway may act as a migration barrier.

On flood plains, the highway fill and bridge openings should be designed to carry the peak flood flow, and should result in minimum impingement upon the flood plain.[32]

Runoff-Borne Pollutants.—Oil, fuel, tar, pesticides, fertilizer, deicing salts (especially in northern areas[33]), animal and human wastes, and the products of combustion are found in highway runoff. If not properly controlled, these pollutants can affect water quality, wildlife, and roadside vegetation. As with the sediment problem, runoff is a non-point-source pollution problem and, as such, is primarily a local responsibility. The impact statement should demonstrate this understanding.

Pollution of the water system by oil and hazardous-materials spills also can be significant, and should be reviewed and assessed by consulting the National Contingency Plan. The reviewer should be familiar with the provisions of this plan and, more important, any appropriate State or local plans for spill prevention and control. Current regulations for spill prevention and control are found in 40 CFR 109. The regional coordinators for oil and hazardous materials should be consulted for the latest guidance under section 311 of the Federal Water Pollution Control Act. If possible, these coordinators should participate directly in the review.

Proposed actions to be taken in the event that spills along highways occur either during construction or after construction should also be considered. A minimum list of items to consider includes

- Probability of spills occurring
- Means of reporting and detecting spills
- Designation of responsible organization for control and cleanup in the project area

Sanitary Wastes.—Highway construction and operation also impacts the water environment via the accumulation and disposal of sanitary wastes. Waste disposal is accomplished through portable toilets during construction and permanent rest areas after construction. While these installations are few in number, they are not insignificant and do come under the point-source discharge limitation and permitting provisions of the new act. In assessing the statement for its completeness, the reviewer must determine that these two methods of waste handling are employed and that raw or inadequately treated discharges are not reaching the water system.

During construction activities work crews must be provided with portable toilets meeting all State health department requirements and any applicable Federal guidelines.

Permanent waste collection and treatment facilities are generally of two types: rest stops and multiple service areas. In either case treatment facilities are usually septic tanks (with drain field) or extended-aeration activated-sludge units. In the event that local municipal facilities are used, the reviewer should determine that future use will not overburden these facilities.

Septic tank systems should be designed and installed in accordance with the "Manual of Septic Tank Practice."[34] Package treatment plants should be discussed from the standpoint of at least maintaining the applicable Federal-State water quality standards. Extended aeration plants lend themselves well to this type of use owing to their minimal BOD and solids residue. Any indication that another process is to be used should be considered carefully by the reviewer.

Sanitary waste impacts also can occur when highway projects are adjacent to current interceptor sewer construction or in-place interceptors. If applicable, the EIS should discuss possible construction accidents that could disturb previously laid or new pipe. Pipe damage and alteration of pipe alinement and grade can result in exfiltration with resulting ground water contamination. This type of impact will occur most frequently in urban areas during freeway and arterial road construction.

Water Supply Protection.—The "Public Health Service Drinking Water Standards"[35] presents maximum concentrations for biological, physical, chemical, and radiological contaminants in water supplies. While these standards are required for interstate water carriers, they function as guidelines for all other public water supplies. Water quality impacts from highway design and construction should be assessed with respect to these standards or, if more stringent, to local standards.

As a general goal, water supply protection should be accomplished as much as possible by minimizing the degradation rather than by increasing treatment of the contaminated waters, especially in rural areas where water treatment costs are quite high. Usually the extent of treatment in rural cities and towns involves chlorination and/or clear well sedimentation.

The statement also should discuss the degree of Federal-State-local water supply agency involvement in project planning. Since protection of local water supplies is a local responsibility, the views of project planners and water supply experts should be set forth. Resolution of opposing views also should be described.

IV.C. NOISE IMPACT REVIEW

IV.C.1. Highway-Related Noise Criteria and Standards

The Noise Control Act of 1972 gives EPA specific authority (among other things) to

- Identify major noise sources, publish noise criteria, and control technology information
- Establish and enforce noise emission standards for products distributed in commerce
- Coordinate Federal research and activities in noise control

The establishment of standards or regulations restricting noise levels from specific types of activities is left to the appropriate Federal agencies.

Pursuant to these goals the Office of Noise Abatement and Control (ONAC) has initiated the following efforts that are directly applicable to highway-related noise:

- Published "Interstate Motor Carrier Noise Emission Standards"[36]
- Published "Public Health and Welfare Criteria for Noise"[37]
- Initiated research on noise effects, results due to be published by October 27, 1973

Until the noise effects document becomes available, the recommended criteria specified in these guidelines should be followed.

For the specific case of highway projects, section 136(b) of the Federal-Aid Highway Act of 1970 (adding sec. 109(i) to title 23 U.S.C.) directs DOT to promulgate ambient noise standards for highway projects. Pursuant to section 109(i), noise standards have been developed and issued as an attachment to the directive on highway noise, "Policy and Procedures Memorandum 90-2."[38]

These standards contain design noise levels for different exterior land uses and activities, and for certain interior uses. EPA is on record, however, as objecting to the standards, as promulgated. Specifically, there is concern that the use of L_{10} values alone may not adequately control certain situations. In addition, it is felt that the L_{10} value of 70 dBA* is too lenient. For example, a steady level of 60-65 dBA during most of the day or night might have a greater impact on residents than shorter periods of 70+ dBA; yet a project of the first type would be entirely acceptable under FHWA PPM 90-2 standards.

*The sound level in decibels on the "A scale" of a standard sound-level meter.

IV.C.2. Review of Noise Impact Analysis

The noise standards require anticipated noise levels to be computed for noise-sensitive areas on the basis of the most adverse conditions expected to occur on the highway in question. This computation is represented as the design noise level during the worst hour of the day during the design year. The analysis should consist of

- An adequate model for relating traffic parameters to estimated noise levels
- Appropriate traffic parameters representing the worst hour of the day during the design year
- Existing noise levels representing the no-project situation

The NCHRP No. 117[39] method for predicting highway noise is the one used at present by EPA. It is emphasized, however, that other acceptable methods may be used by EIS preparers. For example, a new method has been prepared by the DOT Transportation Systems Center (TSC).[40] Although this method has not been tested as extensively as the NCHRP No. 117 method, and no comparisons between the two methods have been made, the TSC approach appears to be at least as good as that of NCHRP No. 117. In general, if the reviewer questions the validity of the model used, ONAC should be consulted.

Figure 5 illustrates the noise analysis inputs and methodology. Except for the roadway gradient and surface conditions, the highway data cover the same range of information required in the air analysis. The notable exception is that here the traffic data from nonpeak diurnal periods are used, because automobile noise increases with the third power (approximately) of the vehicle speed and truck traffic generally is greater during the nonpeak periods. In any case, the traffic data should be reviewed to insure that "worst-case" conditions are used.* A complete set of data must be obtained for each of the areas in which an analysis is required.

As a minimum, the noise analysis should include the L_{10} and L_{50} dBA levels, and should include noise projections after application of chosen noise abatement schemes. Aside from traffic control measures (speed reduction, truck traffic restrictions, etc.), the most effective noise abatement methods involve utilization of buffer zones or the installation or construction of noise abatement barriers or devices.

In conjunction with the predicted noise levels from the highway, the existing noise levels adjacent to the highway must be measured. Sites should be selected both for their proximity to the projected noise source and for their noise sensitivity. L_{10}, L_{50} and L_{90}† levels should be given in dBA units as well as the noise characteristics at the identified test sites. In general, the L_{90} value can be considered as the background level, whereas the L_{10} value is representative of the peak level.

---

*See appendix C for a general discussion of traffic data characteristics.

†The reviewer should note that NCHRP No. 117 cannot be used to predict L_{90} values, since it only provides an L_{50} and an adjustment to L_{10}.

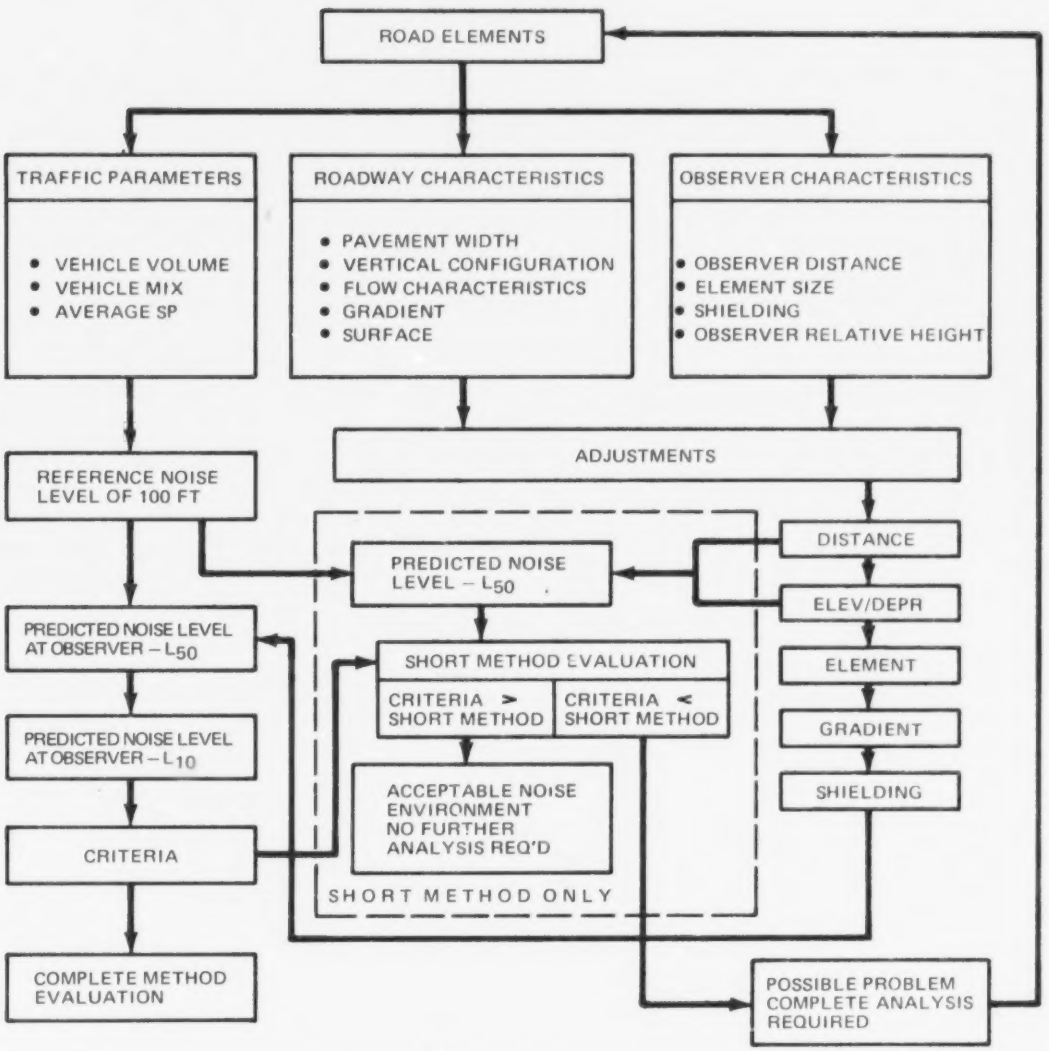

Figure 5.—Noise analysis data and methodology. (From NCHRP No. 117.[39])

Noise impact during the construction phase is both temporary and more difficult to analyze; however, it should also be addressed in the EIS. Estimates of the maximum construction-generated noise at the nearest noise-sensitive area should be stated. In addition, the length of construction, facilities impacted, noise abatement and control measures, noise levels of equipment and operational limits (e.g., time of day, numbers used at one time) should be stated in the EIS.

Possible considerations for noise abatement during construction activities include

- Construction contract specification for use of the quietest equipment available (decibel values should be specified for each type of equipment)
- Construction contract specification containing guaranteed levels of maximum noise emission into various zones (residential, commercial, and industrial)
- Construction contract specification for curfews on hours of construction
- Methods of enforcement for the above clauses

If the reviewer pinpoints apparently sensitive areas or roadway conditions that have not been analyzed, he should first determine that a problem is likely to exist and, if so, then request the appropriate detailed analysis. Proceeding this way, the reviewer places the burden of proof on the EIS preparer, resulting in a better response in the final EIS.

To determine whether there is a problem, the reviewer first must quantify the noise impact by using NCHRP No. 117 and available and assumed worst-case highway-related data as necessary (as defined in NCHRP No. 117 and app. C). In some cases, however, the impact determined for one area can be related to a different area based on comparison of the traffic data, topography, etc., of the two areas. After quantifying the impact, the assessment procedure given in section IV.C.3 should be followed.

IV.C.3. Assessment of Noise Impact

The assessment of the noise impact is simply a judgmental comparison of the anticipated noise levels during the worst hour of the day for the design year, the existing measured ambient noise levels, and the noise criteria for the areas affected.

To determine the applicable noise criteria, the reviewer should determine the existing and anticipated noise-sensitive land uses near the proposed route, particularly those facilities in which speech or sleep occurs (such as residences, motels, hotels, hospitals, and schools, as well as recreational areas such as parks, campgrounds, and nature preserves). For underdeveloped areas a review of the current zoning and any land use plans, including population projections, should be made to anticipate future noise problem areas.

Within each of the noise-sensitive areas, the following criteria should be applied to the noise levels presented.

Speech Communication.* - In residential areas or other areas where conversation out of doors is anticipated, it is desirable to be able to converse at distances up to 12 feet (4 meters).

---

*Pages 19-31 of NCHRP No. 117[39] present similar information and may be used as a guide to recommended criteria for speech communication and for sleep interference (see next paragraph).

As indicated in "Effects of Noise on People" (p. 50, fig. 15),[41] the level of noise at 12 feet should not exceed 55 dBA. This standard would provide interior levels of approximately 45 dBA, assuming open windows for ventilation.

Sleep Interference.—For sleeping purposes a background level of 35 dBA is desirable. Peak levels should not exceed the background level by more than 10 dBA. Thus, peak levels should not exceed 45 dBA. With windows open for ventilation, this recommendation suggests a peak outside level of 55 dBA to protect sleep.

L_{10} Criteria.—Based on EPA's objection to the FHWA's PPM 90-2 standard of L_{10} = 70 dBA, reviewers should treat L_{10} = 70 dBA as a *maximum value* not to be exceeded, with a desirable level less than L_{10} = 70 dBA. Discretion will have to be used in determining the appropriate L_{10} value, but the value should be dependent on existing and future land uses and existing ambient noise level. A correction factor for day-night noise levels may be desired, depending on local conditions.

Although a completed project may not create levels in excess of those recommended, site-by-site consideration must be given to the increase from existing levels. "Community Noise" (ch. 5)[42] indicates that the degree of annoyance experienced from intrusive sounds depends on the noise level increase above existing levels as well as on the existing levels. Some consideration, therefore, must be given to the sites where levels will be increased substantially even if they do not exceed recommended maximum level specifications.

Intermittent excesses (e.g., from truck traffic) should not exceed the range of ambient levels by more than 10 dBA. It is noted that extraordinary events such as very close truck passages or low aircraft flyovers may produce levels that exceed background levels by 25 to 35 dBA. Although people may become acclimatized to such events, considerable annoyance and physical distress are associated with extraordinary noise. Thus, the 10-dBA excursion allowed for infrequent events by the foregoing criterion is conservative. In general then, excesses of less than 5 dBA above the ambient range are acceptable, whereas intermittent peaks of 5 to 10 dBA are only marginally acceptable. Ten- to 15-dBA excesses may signal a potentially serious problem, and peaks greater than 15 dBA would probably initiate strong individual or concerted public action.

Some consideration should be given to additional abatement measures or alternate routing or compensation if the range increase is 5-10 dBA. If the increase is over 10 dBA, the impact is considered serious and warrants close attention.

IV.D. SOLID WASTE MANAGEMENT IMPACT REVIEW

IV.D.1. Highway-Related Solid Waste Management Impacts

The legal and technical requirements for comprehensive planning and integrated solid waste disposal operations are State-local responsibilities.* To date, however, formal regulation of solid waste management practices, other than for public health protection, is in a rudimentary state. In view of these limitations, key elements in the EPA review of the highway impact are

- Determination whether applicable solid waste operations or plans are adversely affected
- In the absence of State or local criteria, determination that existing solid waste operations have been identified and will not be affected adversely

Highway-project-related solid waste impacts can occur from construction operations, disruption of community services (during construction and operation), and roadway operation. Although the impact during the construction period is the most visible, disruption of the community service can produce important long-term problems and should be considered in detail.

IV.D.2. Review of Solid Waste Management Impact Analysis

Construction Impact.–To evaluate the construction impact, the reviewer must be able to

- Identify the types and approximate quantities of disposable materials (spoil) that will be generated
- Determine the disposal methods proposed or available for each type of spoil identified

In general, the proposed methods of disposal should be that subset of available methods which minimizes the total impact (air and water pollution, overloading of existing facilities, routing, etc.). If the spoil competes for available sanitary landfill sites, an estimate of the impact on these sites must be explored. If there is significant impact (such as significant decrease in site lifetime), solid waste disposal alternatives for the user communities also should be described.

If borrow and fill areas are used they must be operated in such a way that the impact, both during and after construction, is minimized. If "sensitive" areas are involved (marshes,

*Pursuant to this concept, the Solid Waste Disposal Act (PL 89-272) authorizes EPA to encourage the enactment of improved and uniform State and local laws governing solid waste disposal.

tidelands, etc.) the requirements of section IV.B must be met. Where possible, topsoil removed during cut or grading operations should be salvaged (i.e., stockpiled) for reuse along the roadway cuts and slopes (as specified in IM 20-6-67[30]).

Spoil from clearing and grubbing operations generally is disposed of by landfilling, burning, or recycling. If the disposal method is burning, the attendant particulate concentrations should be determined and checked against the secondary 24-hour standard. If required, the reviewer can check the concentration values (or make initial estimates) by using the methodology given in Turner's "Workbook."[11] If modeling is used, the input data should reflect the most probable 24-hour average meteorological conditions, and emission factors from AP-42[43] or those determined in consultation with the Emission Factors Branch of the Office of Air and Water Programs. Regardless of the air quality impact, the reviewer should evaluate the merits of recycling as a method of disposal (chipping for mulch, composting, etc.).

Disruption of Community Service.—The EIS must define the amount and nature of disruption to existing solid waste management systems or plans in the project-affected area. The discussion should include adequate solutions to any permanent, serious disruptions or system alterations, as well as comments from State and local sanitation officials. If necessary, the reviewer should obtain independent opinions from such officials.

In communities with established refuse collections or where refuse collection may eventually be established, community isolation can add significantly to collection costs. Although such cases are not common, the reviewer should insure that this possibility has been considered.

Roadway Operations.—Solid waste production during operation of roadways consists, for the most part, of litter accumulation along the roadway and at roadside rest points (sanitary waste impacts are described in sec. IV.B). As a minimum, the EIS should identify the mechanism for the collection and disposal of litter.

IV.D.3. Assessment of Solid Waste Impact

Although any *significant* solid waste impact should influence the project rating, an environmental objection rating (ER and EU) usually is reserved for those projects which

- Utilize improper methods for spoil disposal
- Significantly disrupt or make no attempts to minimize the disruption of existing solid waste disposal operations
- Have not demonstrated compliance with applicable State and local solid waste operations or plans

V. RELATIONSHIP BETWEEN LOCAL SHORT TERM USES OF STUDY AREA AND THE MAINTENANCE AND ENHANCEMENT OF LONG TERM PRODUCTIVITY

For the most part, this analysis category (and the next, sec. VI) are applicable to non-pollutant-related impacts. Although such impacts are not within EPA's areas of expertise, the reviewer is not precluded from commenting in these areas. Comment should be made, however, only if the reviewer has sufficient information and expertise to provide a comprehensive assessment of the probable impact.

From the Council on Environmental Quality guidelines,[6] "This section should contain a brief discussion of the extent to which the proposed action involves tradeoffs between the short term environmental gains at the expense of long term losses, or vice versa, and a discussion of the extent to which the proposed action forecloses future options." Assessment of impacts within this category requires that the reviewer determine the extent of the limitations (if any) placed on future benefits of the project area. For example, projects through estuaries, marshes, etc., may foreclose future choice of use and may permanently impair the natural activity of the area; or elimination of recreation and parklands* can precipitate drastic changes in the social and economic character of the project area. To the extent possible, both primary and secondary impacts should be identified and assessed.

*These areas may also be subject to the Historic Preservation Act[44] and the Department of Transportation Act, 4(f).[45]

Preceding page blank

VI. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE PROPOSED PROJECT

The intent here is to determine that the environmental impact statement has identified properly "the extent to which the action irreversibly curtails the range of potential uses of the environment."[6] As in section V, this review considers a specific category of nonpollutant impacts. Assessments in these areas, *if well posed,* can provide significant inputs to the EPA review response.

Especially noteworthy are project situations that might result in changes in the ecosystem. For example, highways that cut through stream corridors, wetlands, or a natural estuary can result in irretrievable damage to those sensitive biomes. Other impacts that may be irreversible, and hence should be identified, include changes in neighborhood character, loss of recreational areas, loss or alteration of historic sites, and expenditure of construction materials and fuels.

Preceding page blank

VII. PROBABLE ADVERSE IMPACTS THAT CANNOT BE AVOIDED

The probable adverse impacts that cannot be avoided will be the basis for the overall assessment routing of the project.

For each alternative considered, the reviewer should: (a) summarize the probable adverse impacts, and (b) relate the adverse impacts to the proposed project and other alternatives. After all alternatives have been considered the reviewer should be able to determine whether the proposed project both minimizes the environmental impact over all other alternatives and is within acceptable environmental impact limits.

Although these guidelines are mainly concerned with the primary pollutant impacts, to the extent possible, the project assessment rating also should include consideration of secondary pollutant impacts and primary and secondary nonpollutant impacts. The crux of the review assessment is to insure that the EIS contains sufficient information to "explore alternative action that will avoid or minimize adverse impacts and to evaluate both the long- and short-range implications of proposed actions to man, his physical and social surroundings and to nature."[6]

Preceding page blank

VIII. ALTERNATIVES TO PROPOSED ACTION

The primary purpose in considering alternatives is to attempt to mitigate (or eliminate) the unavoidable adverse impacts identified with the proposed project. Each alternative presented should be assessed as fully as possible, using the procedures given in sections IV through VII. Alternatives may be thought of as project related (partial or complete alinement modifications, configuration changes, traffic control, etc.) or project replacement (mass transportation systems, corridor relocations, etc.). At the environmental impact statement (EIS) stage of project development (i.e., "location study" stage), the project replacement alternatives will probably not be included in the EIS. Such alternatives should be suggested, however, if the assessment of the proposed project indicates a significant impact, and if the reviewer is aware that a viable project replacement alternative exists.

In addition to the no-project alternative, the reviewer should determine the applicability of the following types of alternatives:[46]

- No project, with improved traffic flow on existing roadway system. The idea is to eliminate the need for the project (or reduce its scope) by increasing the existing traffic capacity. Several of the more effective techniques for increasing capacity are widened intersections, reversible lanes, one-way streets, traffic responsive control, and loading regulations. For downtown systems, application of the Traffic Operations Program to Increase Capacity and Safety (TOPICS)[47] also should be considered.

- Realinement to improve compatibility between the highway and the surrounding land use. In effect, this realinement is simply "relocating" the right-of-way in such manner that sensitive receptors (or areas) are avoided.

- Realinement to improve highway location and network configuration. Here the distribution of the pollutant capacity at the mesoscale level within the region is used as the criterion for integrating the highway into the existing roadway network.

The effort required for assessment of each alternative will be a function of the type of alternative under consideration. For example, if an alternative alinement is considered for a given highway segment, only the source-receptor relationship will change; the basic traffic data will remain the same. In any case the alternative must be reviewed in sufficient detail to identify *all* impact changes, whether they increase or decrease.

The reviewer should recognize that the EIS consideration of alternatives will, in general, be one of demonstrating why the alternative was unacceptable. In most cases socioeconomic considerations will be a major factor. It is the reviewer's task to

Preceding page blank

- Determine that *all* viable alternatives have been considered
- Determine that their environmental effects have been set forth adequately.
- Review the alternatives from the standpoint of their environmental-impact-mitigation possibilities over the proposed project

REFERENCES

1. U.S. Environmental Protection Agency, Office of Federal Activities, "Basic Documents Concerning Federal Programs to Control Environmental Pollution From Federal Government Activities," rev. ed., Washington, EPA, Dec. 1972.

2. U.S. Department of Transportation, Federal Highway Administration, "PPM 90-1, Guidelines for Implementing Section 102(2)(C) of the National Environmental Policy Act of 1969, Section 1653(f) of 49 U.S.C., Section 470f of 1653 U.S.C., and Section 309 of the Clean Air Act of 1970," Aug. 1971.

3. U.S. Department of Transportation, Federal Highway Administration, "PPM 90-4, Process Guidelines (Economic, Social, and Environmental Effects on Highway Projects)," Sept. 1972.

4. Council on Environmental Quality, "Proposal for Secondary Impacts of Federal Infrastructure Investments," EQC-317, Washington, CEQ, 1972.

5. U.S. Department of Transportation, "Guidelines for the Social and Environmental Assessment of Transportation Alternatives, RFP-DOT-OS-30173," Washington, DOT, Mar. 1973.

6. Council on Environmental Quality, "Preparation of Environmental Impact Statements," 38 *Fed. Reg.* 84, May 2, 1973.

7. National Academy of Sciences-National Research Council, National Academy of Engineering, "Data Requirements for Metropolitan Transportation Planning," National Cooperative Highway Research Program Report 120, Washington, Highway Research Board, Division of Engineering, 1971.

8. Highway Research Board, "Highway Capacity Manual," Special Report 87, Division of Engineering and Industrial Research, Washington, National Academy of Sciences-National Research Council, 1965.

9. American Association of State Highway Officials, "A Policy on Geometric Design of Rural Highways," Washington, AASHO, 1965.

10. American Association of State Highway Officials, "A Policy on Arterial Highways and Urban Areas," Washington, AASHO, 1965.

11. Turner, D. B., "Workbook of Atmospheric Dispersion Estimates," rev. ed., U.S.P.H.S. Publication No. 999-AP-26, Cincinnati, U.S. Department of Health, Education, and Welfare, 1969.

12. Larsen, R. I., "A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards," Office of Air Programs Publication No. AP-89, Research Triangle Park, N.C., Environmental Protection Agency, Nov. 1971.

13. Darling, E. M., Jr., "Computer Modeling of Transportation-Generated Air Pollution, A State-of-the-Art Survey," Report No. DOT-TSC-OST-72-20, Washington, U.S. Department of Transportation, June 1972.

14. Calder, K. L., "Air Pollution Concentrations From a Highway in an Oblique Wind," unpublished manuscript, Research Triangle Park, N.C., Environmental Protection Agency, Division of Meteorology, 1972.

15. Zimmerman, J. R., and Thompson, R. S., "An At-Grade Highway Pollution Dispersion Model," unpublished manuscript, Research Triangle Park, N.C., Environmental Protection Agency, Division of Meteorology, undated.

16. Beaton, J. L., Skog, J. B., Shirley, E. C., and Ranzieri, A. J., "Mathematical Approach to Estimating Highway Impact on Air Quality," Sacramento, State of California, California Division of Highways, Report No. CA-HWY-MR 657082S-4-72-12, May 1972.

17. Beaton, J. L., Skog, J. B., Shirley, E. C., and Ranzieri, A. J., "Meteorology and Its Influence on the Dispersion of Pollutants From Highway Line Sources," Sacramento, State of California, California Division of Highways, Report No. FHWA-RD-72-33, Apr. 1972.

18. Beaton, J. L., Skog, J. B., Shirley, E. C., and Ranzieri, A. J., "Motor Vehicle Emission Factors for Estimates of Highway Impact on Air Quality," Sacramento, State of California, California Division of Highways, Report No. FHWA-RD-72-34, Apr. 1972.

19. Beaton, J. L., Skog, J. B., Shirley, E. C., and Ranzieri, A. J., "Traffic Information Requirements for Estimates of Highway Impact on Air Quality," Sacramento, State of California, California Division of Highways, Report No. FHWA-RD-72-35, Apr. 1972.

20. Beaton, J. L., Skog, J. B., Shirley, E. C., and Ranzieri, A. J., "Analysis of Ambient Air Quality for Highway Environmental Projects," Sacramento, State of California, California Division of Highways, Report No. FHWA-RD-72-38, Apr. 1972.

21. Stanford Research Institute, "User's Manual for the APRAC-1A Urban Diffusion Model Computer Program," SRI, Menlo Park, Calif., Sept. 1972.

22. Danard, Maurice B., "Numerical Modeling of Carbon Monoxide Concentrations Near Highways," *J. Appl. Meteorol. 11*(6), 947-957, 1972.

23. Sklarew, R. C., Fabrick, A. J., and Proger, J. E., "Atmospheric Simulation Modeling of Motor Vehicle Emissions in the Vicinity of Roadways," presented at the 1972 Summer Computer Simulation Conference, San Diego, June 14-16, 1972.

24. Kirschner, D. S., and Armstrong, D. P., "An Interim Report on Motor Vehicle Emission Estimation," Research Triangle Park, N.C., Environmental Protection Agency, Office of Air and Water Programs, Aug. 1973.

25. "Requirements for Preparation, Adoption, and Submittal of Implementation Plans," 36 *Fed. Reg.* 15486, Aug. 1971.

26. Task Force on Hydrology and Hydraulics, AASHO Operating Subcommittee on Roadway Design, "Guidelines for Hydrology, Volume II–Highway Drainage Guidelines," Washington, AASHO (341 National Press Building), 1973.

27. U.S. Environmental Protection Agency, Water Programs Office, "Control of Erosion and Sediment Deposition From Construction of Highways and Land Development," Washington, EPA, Sept. 1971.

28. U.S. Environmental Protection Agency, Office of Research and Monitoring, "Guidelines for Erosion and Sediment Control Planning and Implementation," Washington, EPA, Aug. 1972.

29. U.S. Department of Transportation, "Instructional Memorandum 20-3-70, Prevention, Control, and Abatement of Water Pollution Resulting from Soil Erosion," Apr. 30, 1970.

30. U.S. Department of Transportation, "Instructional Memorandum 20-6-67, Prevention, Control, and Abatement of Water Pollution Control by Federal Activities--Executive Order 11288," Dec. 29, 1967.

31. U.S. Soil Conservation Service, "Agricultural Information Bulletin No. 347, Control Erosion on Contract Sites," Washington, SCS, Dec. 1970.

32. Bureau of Public Roads, "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," FP-69, Washington, U.S. Department of Transportation, Federal Highway Administration, BPR, 1969.

33. National Cooperative Highway Research Program, "Effects of Deicing Salts on Water Quality and Biota, Literature Review and Recommended Research," Report 91, Highway Research Board, Washington, 1970.

34. U.S. Public Health Service, "Manual of Septic-Tank Practice," rev. ed., U.S.P.H.S. Pub. No. 526, Washington, U.S. Government Printing Office, 1967.

35. U.S. Public Health Service, "U.S. Public Health Service Drinking Water Standards," U.S.P.H.S. Pub. No. 956, Washington, U.S. Government Printing Office, 1962.

36. "Interstate Motor Carrier Noise Emission Standards," 40 CFR Part 202, 38 *Fed. Reg.* 20102, July 27, 1973.

37. U.S. Environmental Protection Agency, "Public Health and Welfare Criteria for Noise" (draft), Washington, EPA, Office of Noise Abatement and Control, July 9, 1973.

38. U.S. Department of Transportation, Federal Highway Administration, "PPM 90-2, Subject: Noise Standards and Procedures," Feb. 1973.

39. Highway Research Board, "Highway Noise, A Design Guide for Highway Engineers," NCHRP 117, Washington, HRB, 1971.

40. U.S. Department of Transportation, Transportation Systems Center, "Manual for Highway Noise Prediction (Short Version)," Washington, DOT, Mar. 1972.

41. U.S. Environmental Protection Agency, "Effects of Noise on People," NTID 300.7, Washington, EPA, Dec. 31, 1971.

42. U.S. Environmental Protection Agency, "Community Noise," NTID 300.3, Washington, EPA, Dec. 31, 1971.

43. U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," Report AP-42, 2d ed., Research Triangle Park, N.C., EPA, Office of Air Programs, Apr. 1973.

44. Sec. 470(f), 16 U.S.C. (Sec. 106 of the Historic Preservation Act of 1966).

45. Department of Transportation Act, Section 4(f), "Maintenance and Enhancement of Natural Beauty of Land Traversed by Transportation Lines." (Federal Aid to Highways Act of 1970.)

46. U.S. Environmental Protection Agency, Office of Air Programs, "A Guide for Reducing Air Pollution Through Urban Planning," Washington, EPA, Dec. 1971.

47. U.S. Department of Transportation, Federal Highway Administration, "PPM 21-18, Urban Traffic Operations Program to Increase Capacity and Safety," 23 U.S.C. 135, May 1972.

APPENDIX A

AIR QUALITY CONTROL REGIONS THAT INCLUDED TRANSPORTATION CONTROLS AS PART OF THEIR SIP

State	*Air Quality Control Region*
Alaska	Northern Alaska Intrastate
Arizona	Phoenix-Tucson Intrastate
California	San Francisco Bay Area Intrastate
	Sacramento Valley Intrastate
	Metropolitan Los Angeles Intrastate
	San Joaquin Valley Intrastate
	San Diego Intrastate
Colorado	Metropolitan Denver Intrastate
District of Columbia	National Capital Interstate
Maryland	National Capital Interstate
	Metropolitan Baltimore Interstate
Illinois	Metropolitan Chicago Interstate
Massachusetts	Metropolitan Boston Intrastate
Minnesota	Minneapolis-St. Paul Intrastate
New York	New Jersey-New York-Connecticut Interstate
New Jersey	New York-New Jersey-Connecticut Interstate
Pennsylvania	Metropolitan Philadelphia Interstate
	Metropolitan Philadelphia Interstate
	Southwest Pennsylvania Intrastate
Nevada	Clark-Mohave Interstate
Ohio	Metropolitan Dayton Intrastate
Oregon	Portland Interstate
Texas	Metropolitan San Antonio Intrastate
	Metropolitan Dallas-Fort Worth Intrastate
	Austin-Waco Intrastate
	El Paso, Las Cruces, et al.
	Corpus Christi-Victoria Intrastate
	Metropolitan Houston-Galveston Intrastate
Utah	Wasatch Front Intrastate
Washington	Puget Sound Intrastate
	Eastern Washington-Northern Idaho Interstate

APPENDIX B

AIR IMPACT FORECAST PROCEDURE FOR CARBON MONOXIDE

In conducting the review of the level 2 air analysis (1-hour and 8-hour CO), it may be necessary to spot-check air quality concentration values presented in the environmental impact statement (EIS), estimate concentration values for critical situations not covered by the EIS, or estimate the general impact level of the project if no analysis is presented.

In each case the recommended modeling technique is the Hiway line source diffusion model.[15] This model is implemented at the Computer Center, Research Triangle Technical Center (RTTC), Durham, North Carolina (stored on the Unamap file), and is maintained by the Meteorology Branch, Office of Research and Development. All regional offices are on-line to the computer at RTTC and should be able to use this model.

Spot Check.—This situation assumes that a rather comprehensive air analysis has been presented in the EIS, but that the reviewer questions the order of magnitude of the concentration values presented. If an analysis technique other than diffusion modeling has been used, spot checking is especially important. If the spot checks do compare favorably* and the overall EIS analysis procedure shows no individual inadequacies, the EIS results should be accepted.

Supplemental Estimate at Critical Areas.—If a satisfactory analysis has been made but the reviewer has identified critical situations that were not considered, he should estimate the concentration levels at these points. It is advisable that the reviewer first spot check other data points to verify the predictive consistency of his technique with the general analysis given.

Maximum Impact Estimate.—If an unsatisfactory air quality analysis has been presented, or if any of the data leading to the air quality estimates are deemed inadequate, the reviewer should estimate the concentration values at several points along the right-of-way. Following is suggested procedure.

1. Approximate the maximum 1-hour CO impact at the closest right-of-way line by using the Hiway diffusion model and an assumed set of worst-worst conditions. This estimate is a quick first step to get an indication of the impact, and thus is an indication of how much effort should go into precise definition of missing data.

---

*The reviewer should recognize, however, that precise comparison of results between the EIS technique and the EPA technique is not required.

Preceding page blank

a. If peak- (worst-) hour data are missing, use figure C-7 to estimate peak volume from the maximum annual average daily traffic (AADT) value (if AADT is missing and a reasonable estimate cannot be made, rate the air portion of the EIS as inadequate and terminate air quantification). Depending on the type of roadway, a directional split may be required. This requirement is a function of the roadway location and should be judged by the reviewer.

b. If average speed data are missing, estimate from figure C-11 or C-12 as possible.

c. Utilize EPA emission factors[24] with national average assumptions as required.

d. If meteorological data are missing, assume: wind speed of 1 meter per second, wind flow parallel to roadway, and "E" stability.

e. Estimate background concentration from State implementation plan.

f. Calculate the 1-hour CO concentration contribution from project, and add background.

2. If the 1-hour CO value is less than 10 ppm, the project should not adversely affect the area and no further analysis is necessary. If the 1-hour CO value is greater than 10 ppm, a detailed analysis (utilizing "realistic" data) should be requested. For controversial projects, the reviewer may wish to utilize available realistic data in the analysis before requesting further analyses in the EIS.

Figure B-1 illustrates an acceptable procedure for analyzing the realistic 1-hour and 8-hour CO concentration levels. The procedure is shown in a form that could be recommended to the EIS preparer. For use by the reviewer, the procedure would be modified by the substitution of assumed data for measured data, where necessary.

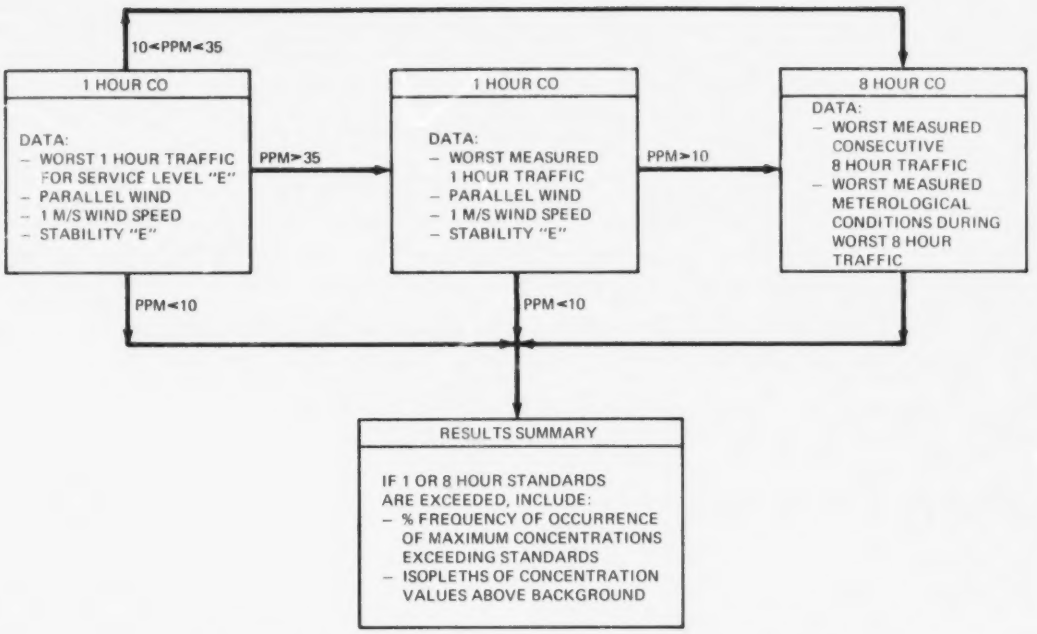

Figure B-1.—CO quantification as a function of impact.

APPENDIX C

GENERAL CONCEPTS OF TRAFFIC FLOW AND SPEED CHARACTERISTICS

Before proceeding, the reader should note the following definitions:

Average annual daily traffic. The total yearly volume divided by the number of days in the year, commonly abbreviated as AADT.

Average highway speed. The weighted average of the design speeds within a highway section, when each subsection within the section is considered to have an individual design speed.

Capacity. The maximum number of vehicles that has a reasonable expectation of passing over a given section of a lane or a roadway in one direction (or in both directions for a two-lane or a three-lane highway) during a given time period under prevailing roadway and traffic conditions.

Design speed. A speed selected for purposes of design and correlation of those features of a highway, such as curvature, superelevation, and sight distance, upon which the safe operation of vehicles is dependent.

Level of service. This term, broadly interpreted, denotes any one of an infinite number of differing combinations of operating conditions that may occur on a given lane or roadway when it is accommodating various traffic volumes. The two parameters that define the level of service are the operating speed and the ratio of volume to capacity (v/c) (see fig. C-1).

Level of service A. A condition of free flow, with low volumes and high speeds. Traffic density is low, with speeds controlled by driver desires, speed limits, and physical roadway conditions. There is little or no restriction in maneuverability due to the presence of other vehicles, and drivers can maintain their desired speeds with little or no delay.

Level of service B. In the zone of stable flow, with operating speeds beginning to be restricted somewhat by traffic conditions. Drivers still have reasonable freedom to select their speed and lane of operation. Reductions in speed are not unreasonable, with a low probability of traffic flow being restricted. The lower limit (lowest speed, highest volume) of this level of service has been associated with service volumes used in the design of rural highways.

Preceding page blank

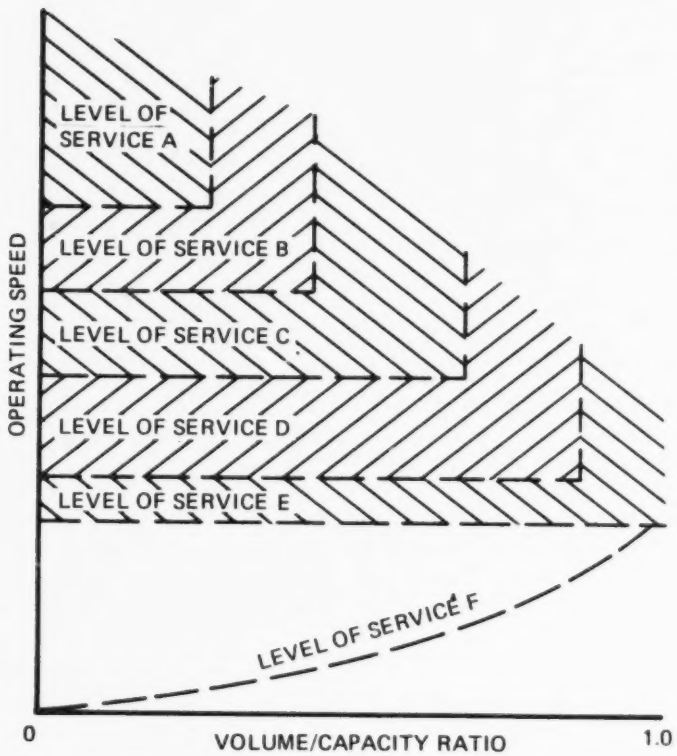

Figure C-1.—General concept of relationship of levels of service to operating speed and volume capacity ratio. (Not to scale.)

Level of service C. Still in the zone of stable flow, but speeds and maneuverability are more closely controlled by the higher volumes. Most of the drivers are restricted in their freedom to select their own speed, change lanes, or pass. A relatively satisfactory operating speed is still obtained, with service volumes perhaps suitable for urban design practice.

Level of service D. Approaches unstable flow, with tolerable operating speeds being maintained though considerably affected by changes in operating conditions. Fluctuations in volume and temporary restrictions to flow may cause substantial drops in operating speeds. Drivers have little freedom to maneuver, and comfort and convenience are low, but conditions can be tolerated for short periods of time.

Level of service E. Cannot be described by speed alone, but represents operations at even lower operating speeds than in level D, with volumes at or near the capacity of the highway. At capacity, speeds are typically, but not always, in the neighborhood of 30 mph. Flow is unstable, and there may be stoppages of momentary duration.

Level of service F. Force flow operation at low speeds, where volumes are below capacity. These conditions usually result from queues of vehicles backing up from a restriction downstream. The section under study will be serving as a storage area during parts or all of the peak hour. Speeds are reduced substantially and stoppages may occur for short or long periods of time because of the downstream congestion. In the extreme, both speed and volume can drop to zero.

Operating speed. The highest overall speed at which a driver can travel on a given highway under favorable weather conditions and under prevailing traffic conditions without at any time exceeding the safe speed as determined by the section-by-section design speed.

Peak-hour traffic. The highest number of vehicles found to be passing over a section of a lane or a roadway during 60 consecutive minutes.

Volume. The number of vehicles that pass over a given section of a lane or a roadway during a time period of 1 hour or more. Volume can be expressed in terms of a lane or a roadway during a time period of 1 hour or more. Volume can be expressed in terms of daily traffic or annual traffic, as well as in hourly terms.

These terms will be used throughout this appendix without further definition. Of particular importance is the concept of the "level of service." It is the design level of service that dictates the highway configuration (number of lanes, number of interchanges, section changes, etc.) and thus the free flow capacity of the roadway. If the design level of service is too low (e.g., level C instead of level B) traffic congestion will result and the predicted average speeds will not be maintained. This concept will be described in more detail.

When hourly traffic counts for a full year are available, it is possible to show the distribution of hourly volumes by arranging these volumes in descending order of magnitude. Figure C-2 shows such a curve in terms of total volume measured. By constructing curves of this sort, which are representative of the project conditions (i.e., similar area, highway design, etc.), the design hourly volume (DHV) most suitable for the project may be determined. The suitability of the DHV value is usually a compromise between annual service provided and cost. For example, consider figure C-2 as representative of the proposed project conditions. Fifty percent of the year the volume is 235 vehicles per hour (vph) or less; however, only 13 percent of the annual traffic flow occurs during these hours.

A DHV based upon a flow of 235 vph or less would cause 87 percent of the annual traffic flow to operate under inadequate service conditions. On the other hand, if the maximum record hourly volume of 1,575 vph were utilized as the DHV, the highway would have substantial excess capacity during all but 1 hour of the year, an "economically unfeasible situation." Customary practice has been to use a DHV value between the 10th and 50th highest hourly volume (frequently the 30th). It should be noted that, in the example of figure C-2, the peak volume is greater than twice the 30th-hour volume, which illustrates the danger in using the DHV instead of the peak volume for air quality calculations.

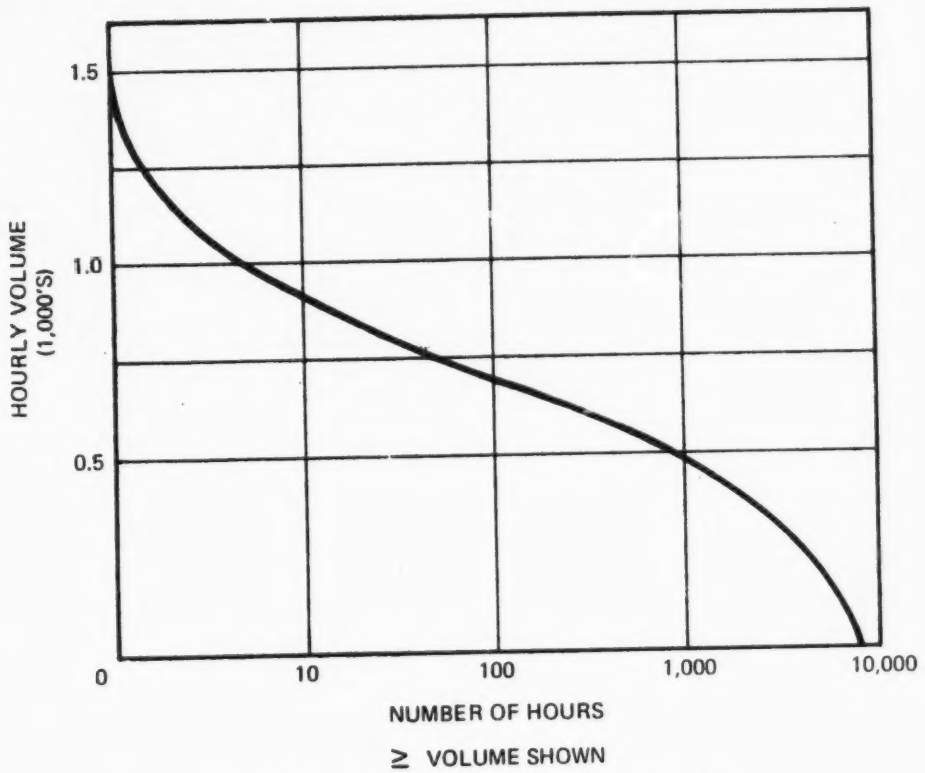

Figure C-2.—Example variation of hourly traffic.

For most existing highway systems, continuous volume counts are available at only a limited number of locations. As a result, the construction and application of hourly traffic volume curves must reflect special precautions to include the peak traffic situations that could occur over the diurnal, weekly, and seasonal time cycles.

Figure C-3 shows, in terms of percent average daily traffic (ADT), a typical weekday diurnal cycle for both urban and rural highways. In addition, it may be important to look separately at the hourly traffic variation on weekends. Figure C-4 shows how these daily variations can look. In this relationship, the weekday travel is dominated by commuter traffic, while the Sunday traffic is no doubt recreational. Even though the three separate peaks are equal in magnitude, temporal changes in meteorology may cause one peak to be more important than the others.

Daily changes are shown in figure C-5. Here the characteristics of urban and rural traffic are contrasted. The urban traffic stays at about the same level during the week, increases as the weekend traffic begins to leave town on Friday, and falls to a low on Sunday. The rural traffic pattern is generally opposite.

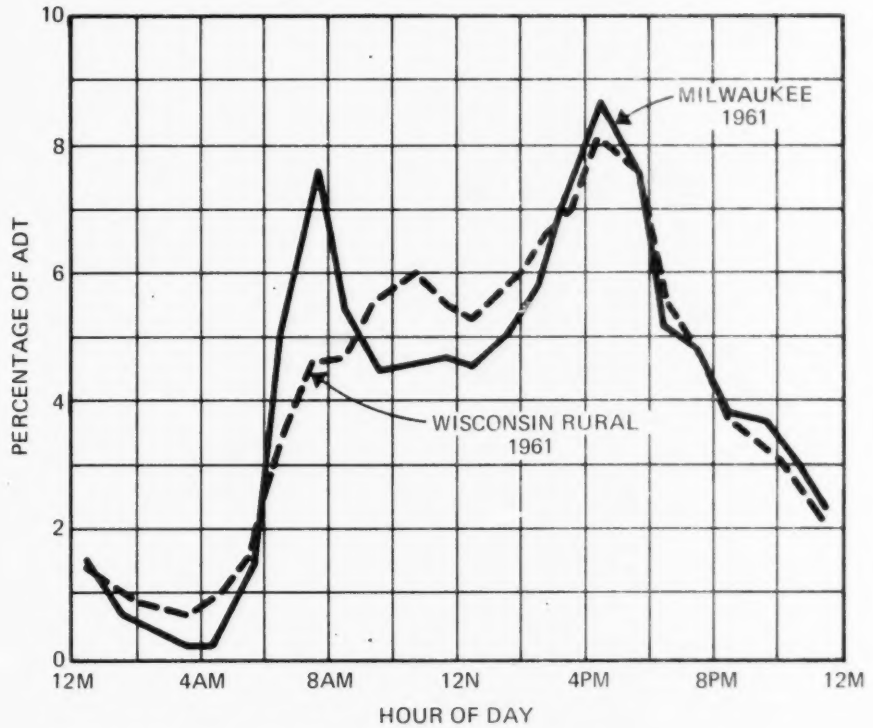

Figure C-3.—Example hourly variations of traffic for average weekday.

Seasonal variations also may be considerable and, when combined with associated meteorological regimes, may be very important. Figure C-6 shows variations which may occur. The data for the State of Washington show comparatively little seasonal variation in urban traffic and high variation in rural traffic due to recreational travel. When the Tucson urban area traffic is compared with Washington urban traffic, the effect of climate can be seen easily.

To aid the traffic engineer in relating annual traffic volumes and peak hourly flows, the "Highway Capacity Manual"[8] contains an analysis of traffic data collected during 1961 and 1962 throughout the United States. Figure C-7 summarizes these results. In the absence of peak-hour data, the reviewer can use these curves to estimate the peak-hour volume from the AADT. There are two pitfalls in relating annual average daily traffic (AADT) to traffic flows. First, sampling must be conducted to estimate the AADT and not highway capacity. High constant traffic flows throughout the day indicate that the AADT is not actually being measured. Second, if the highway is near capacity use, the peak use will be less than that predicted by the 30th-hour method, since the 30th-hour factor decreases with increased highway use.

Since pollutant dispersion is enhanced by distance from the source, the lateral location of slow-moving and congested traffic is important to the immediate downwind receptor,

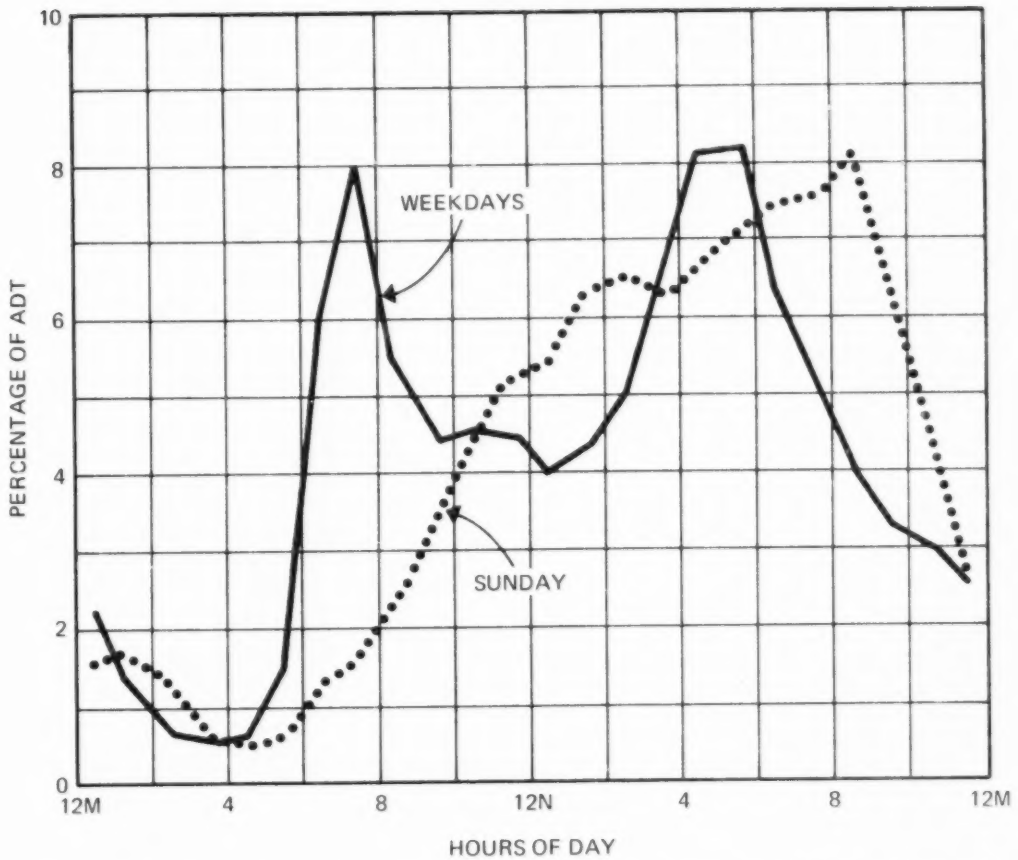

Figure C-4.—Example hourly variations of daily traffic. (From the "Highway Capacity Manual."[8])

especially on highways with many lanes and wide medians. For this reason, it is sometimes necessary to separate the total traffic flow into lane-by-lane components. The proportioning of the total flow must consider both the directional and lane distributions.

On most two-way highways the AADT has been found to be approximately the same in each direction for most 24-hour volumes, but holidays and weekend travel can cause an unbalanced total flow on specific days. The volume during any specific hour, however, may be much heavier in one direction than in the other; usually the inbound traffic dominates in the morning and outbound in the evening.

The distribution of traffic between lanes for one direction of flow depends on several factors, including traffic volume, medial and marginal friction, proportion of slow-moving vehicles, and the number and location of ingress and egress points.

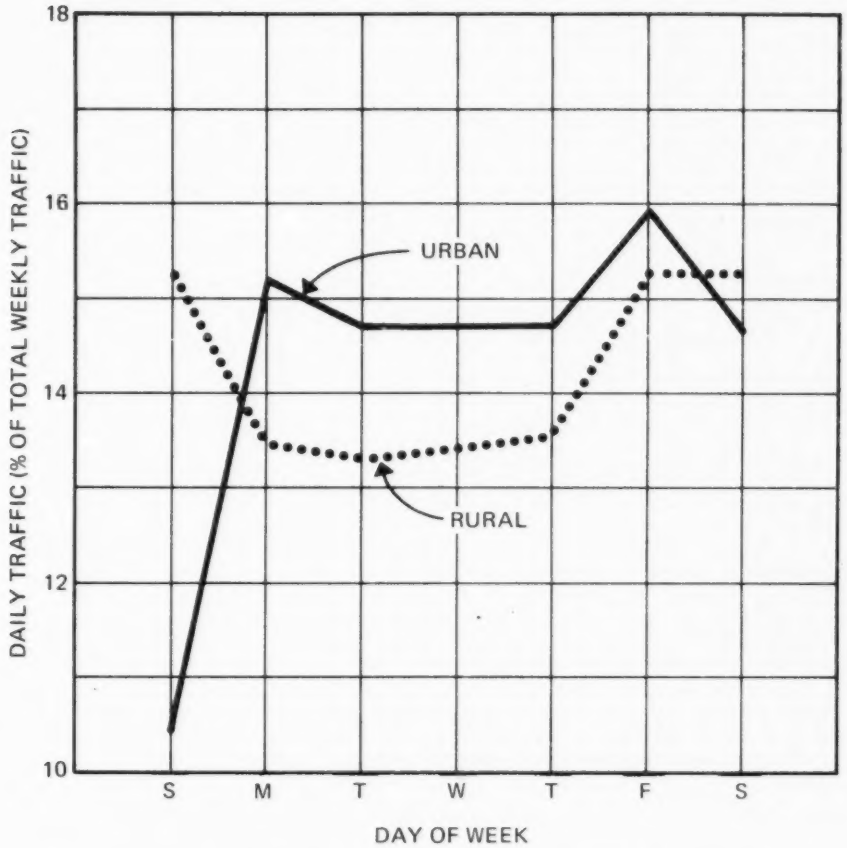

Figure C-5.—Example daily changes in traffic. (From the "Highway Capacity Manual."[8])

Figure C-8 illustrates the variation that can occur between lanes. This figure shows average lane distributions in one direction found on selected six-lane freeways at various volumes. Note that at the larger flow rates the fast lanes (2 and 3) account for about 70 percent of the traffic volume.

Since the AADT projections are the key data inputs, it is important that all factors influencing these projections are accounted for. The AASHO Policy on Geometric Design,[9] which, although somewhat out of date, is still used by most highway departments, defines both the primary and secondary traffic growth parameters as follows:

Normal Traffic Growth. Normal traffic growth is the increase in traffic volume due to general increase in number and usage of motor vehicles.

From the past trend, the motor vehicle travel may be projected to the future year for which the design is to be made. This may be done by plotting a curve of total vehicle miles against years,

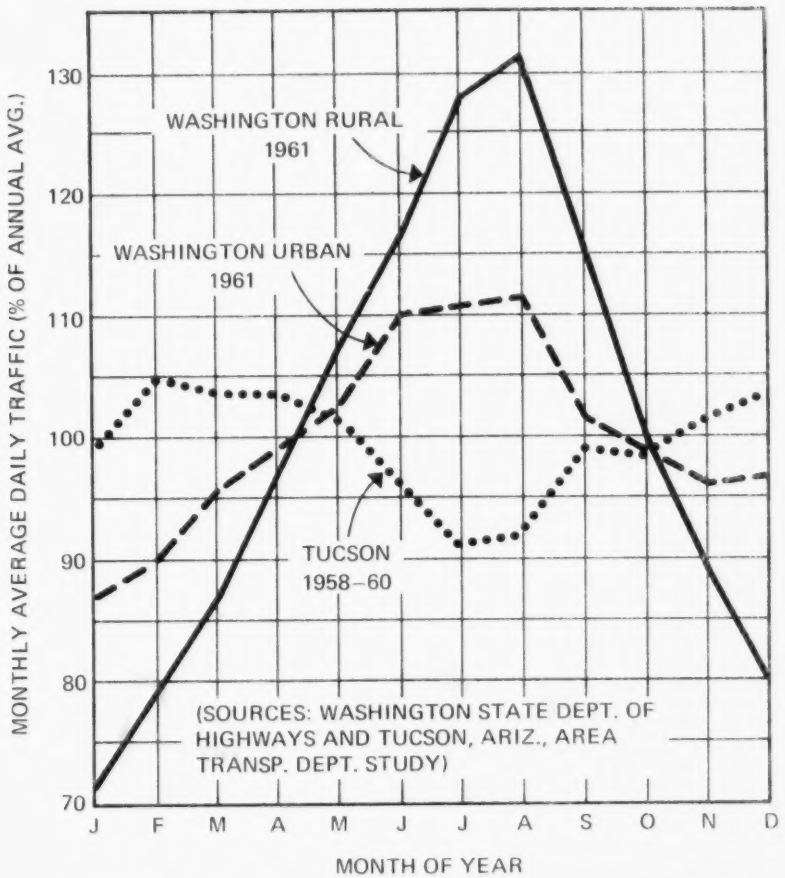

Figure C-6.—Examples of monthly traffic volume variations.
(From the "Highway Capacity Manual."[8])

similar to Figure [C-9] and projecting the curve by judgment to the year desired. For an area, a more accurate analysis may be performed by plotting separate curves for area population, number of vehicles per unit of population in the region, and average miles of travel per vehicle based on local gasoline consumption. The product of these three values taken from the curves for the year chosen for design gives the total vehicle miles of travel for that year. The dashed line in Figure [C-9] is a travel forecast for a selected State evolved from such an analysis.

For any one facility, estimates for the increase in normal traffic should be based on trends and estimates for the region, State or locality in which the highway is situated.

Generated Traffic. Generated traffic consists of motor vehicle trips (other than by public transit) that would not have been made if the new facility had not been provided. Generated traffic is made up of three categories: new trips not previously made by any mode of travel; trips that previously were made by public transit and trips that previously were made to a different destination, but for which the change is attributable to the attractiveness of the improved highway and not to change in

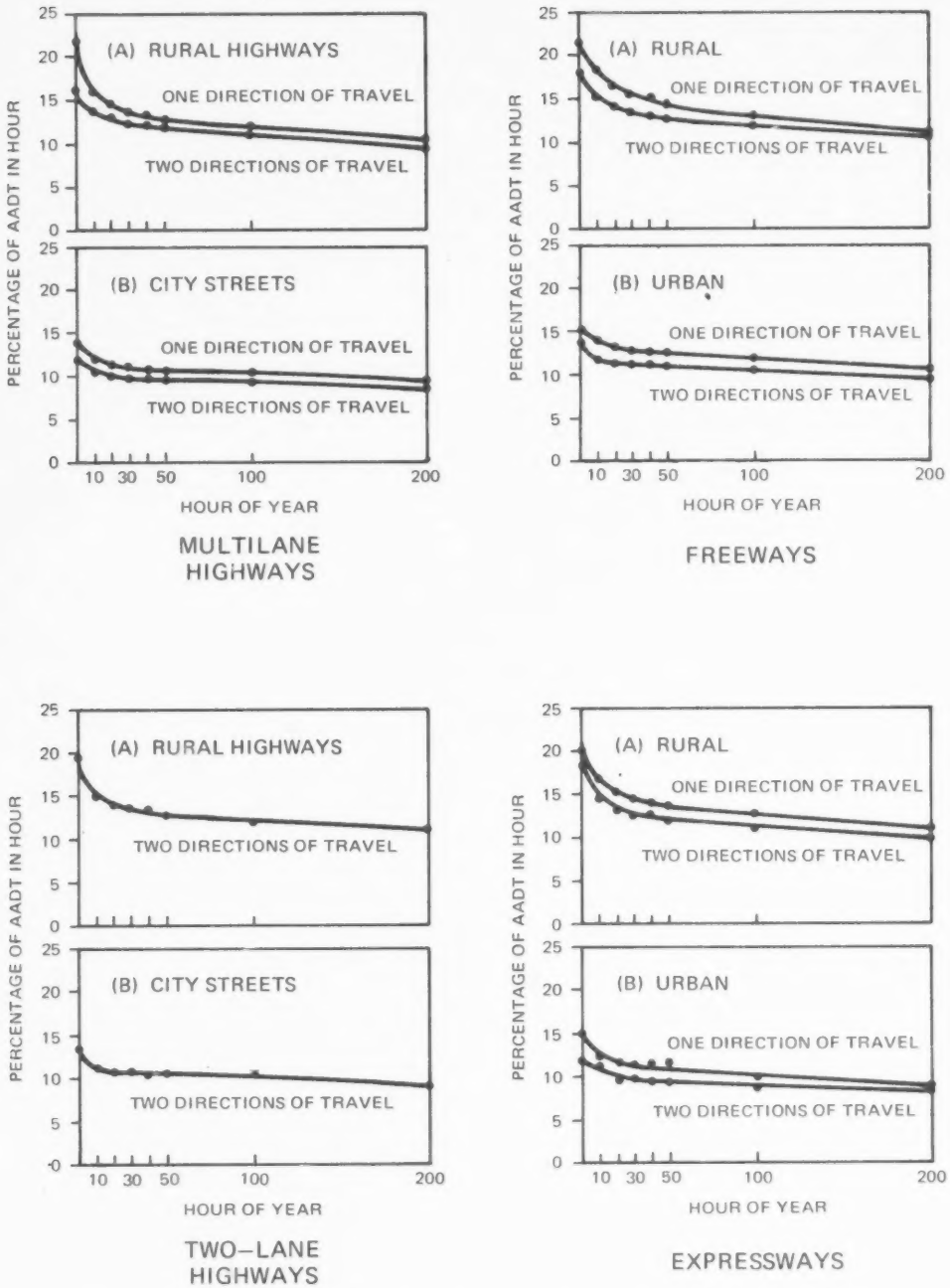

Figure C-7.—Relation of hourly volumes and annual average daily traffic.
(From the "Highway Capacity Manual."[8])

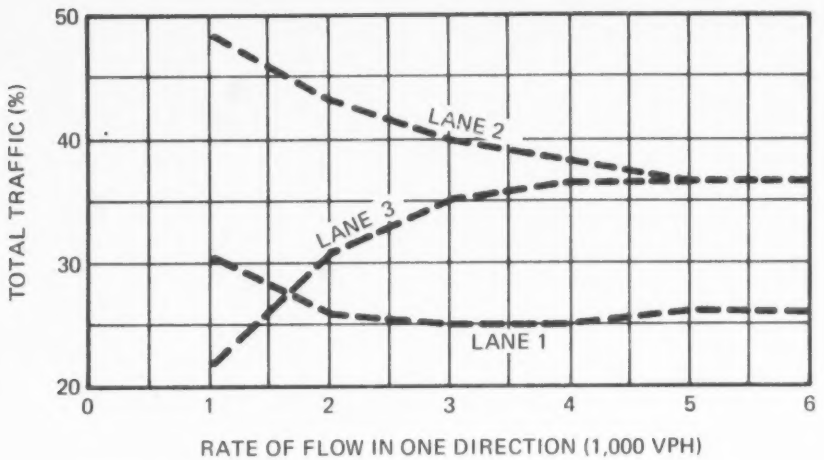

Figure C-8.—Example traffic volume variation between lanes (six-lane facility). (From the "Highway Capacity Manual."[8])

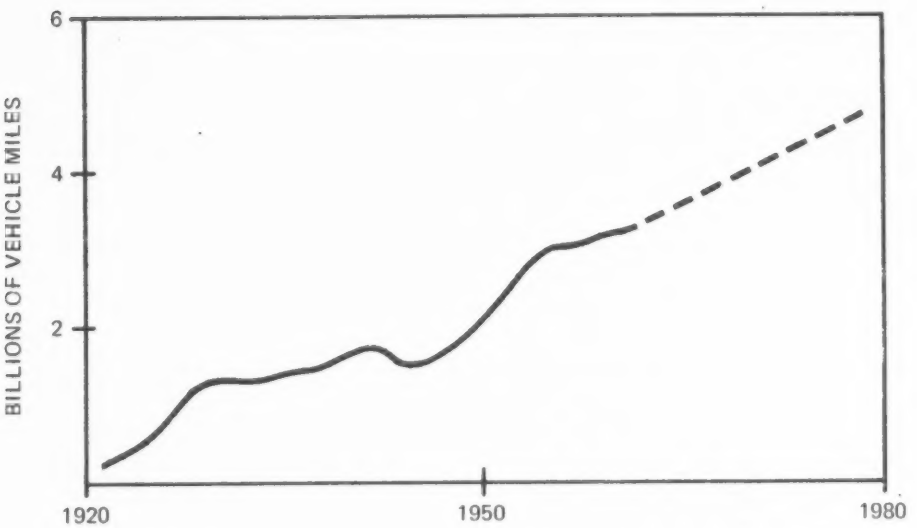

Figure C-9.—Total motor vehicle travel and forecast for a selected State. (From "A Policy on Geometric Design of Rural Highways."[9])

land use. Regardless of the reason for generated traffic the net result is traffic increase on a given improvement. Most of this traffic develops within the first year or two after a new highway is opened.

The amount of generated traffic that materializes on any one improvement may vary considerably, depending primarily on the type and extent of improvement, character of other highways in the area, and land use. Improvements that are small in scope or those that do not materially improve operating conditions are apt to produce little generated traffic. On the other hand, traffic on a new highway to a resort development may be composed almost entirely of generated traffic. For example,

a type of highway on which it is pleasant, relaxing and safe to drive as a controlled access highway, generates more traffic than one with frequent interference, annoyance, and hazard. Arterial highway improvements that lead to destinations with adequate parking facilities usually create many more new trips than similar improvements where the parking situation is critical. Highway improvements in areas where public transit or other modes of transportation are inadequate generally produce more generated traffic than those in areas where other transportation means are, or are made attractive. As in the case of attracted traffic, the amount of generated traffic may depend upon the capacity and the volume on existing roads that are relieved by the improved highway.

Little information is available on generated traffic. There are not many examples, and often traffic is measured so that the increase called generated traffic includes other forms of traffic growth.

In establishing the traffic volume for the design of a highway, generated traffic should be included as component even though it may be based upon judgment only. For most rural highways generated traffic as herein defined is likely to run 5 percent or over but rarely as much as 25 percent.

Development Traffic. Development traffic is that due to improvement on adjacent land over and above the development which would have taken place had not the new or improved highway been constructed. In interstate analysis this has been referred to as the "L" factor or the percentage increase over a statewide increase to allow for greater development along a highway than throughout a State. This component of future traffic, unlike that of generated traffic, continues to develop for many years after a new facility is constructed. Increased traffic due to normal development of adjacent land is included in normal traffic growth, but experience with many improved highways indicates that adjacent land is developed more rapidly than land elsewhere. The traffic resulting therefrom should be accounted for in estimating future traffic volume.

When a rural highway is a freeway, as in Interstate analysis, there is likely to be development traffic resulting from abnormal development along the freeway, near interchanges or along crossroads having interchange with the freeway. A factor to allow for traffic above that resulting from land development due to such abnormal land development may be appropriate.

In strictly rural areas that are well removed from cities and villages, this type of traffic growth is apt to be less significant than in the near urban areas. In some instances, it can be neglected altogether with the assumption that the normal traffic growth accounts for traffic due to all land development. In urban and suburban areas, and in rural areas between a city and satellite communities, traffic resulting from rapid development of adjacent land generally will be significant.

The method of obtaining development traffic may not be precise and the volumes obtained are only approximate, but in many cases the volume from this cause is appreciable. The omission of this item in estimating future traffic might explain why the volumes for a number of prominent improvements in the past proved to be underestimated.

It cannot be overemphasized that underprediction of the project utilization leads to an underprediction of its environmental impact. If the estimated AADT is low, the estimated peak volume will be low and the average speed will be high, all of which would produce underestimated pollutant concentration values. The reviews *must* insure that a comprehensive analysis of the traffic projection data has been made.

For the mesoscale analysis, the vehicle speed that must be utilized with the emission factors is the average trip speed representative of the time period of interest (8-hour CO, 3-hour HC, or annual average NO_x).

The average trip speed (i.e., overall travel speed, or journey speed) is defined as the distance covered, divided by the elapsed time. This speed reflects the amount of acceleration, deceleration, and idle modes of engine operation, as well as cruise conditions for a given roadway or system of roadways. Average trip speed on urban and suburban arterials with uncoordinated signals and a 25-mph speed limit normally will range between 15 and 22 mph.[16] Downtown streets may operate at the lower limit of stable flow conditions with an overall travel speed of about 10 mph.[16]

For the microscale analysis, the vehicle speed must reflect the average operating speed of the particular lane (or lanes if the total roadway is considered a single source) under consideration. Following is a description of the speed variation characteristics of individual roadways.

As with traffic volumes, speed distributions and averages have significant diurnal variations. These variations are a result of many influences, the most notable of which are the volume-capacity effects. Typically, speed reduction accompanies volume increases during rush-hour conditions. Figure C-10 shows an example of such a relationship. In this case the minimum speed occurred during the morning peak. During the afternoon peak, however, a lesser volume increase did not result in a speed reduction; instead, it was accompanied by a slight *increase* in average speed. This phenomenon is often due to differences in the driver population. During the morning peak, traffic is principally a clean buildup of home-to-work drivers; but in the afternoon the peak period may include the transition from the more casual midday drivers to the work-to-home group.

For any given time of day, there is also a variation in average speed for each lane of multilane freeways. In general, the slowest average speed occurs at the shoulder lane (lane 1). Other factors influencing differential lane speeds are the number of entrances and exits. Interestingly enough, lane 1 generally is influenced the least by the entrances and exits. As the volume increases, however, these effects diminish and the lane speed differential becomes less.

In general, the speed/flow relationship for freeways are somewhat curved, reflecting faster speeds at intermediate flow rates than are found on other types of highways. Figure C-11 illustrates the typical relationship between operating speed and volume, given ideal uninterrupted flow conditions, on freeways and expressways. Curves for less than ideal average highway speeds are also shown. The curves in figure C-11 were developed from data on file at the Bureau of Public Roads. They portray actual hourly volumes having a high peak-hour factor (that is, constant high traffic demand throughout the hour). The shaded area at the right represents highly unstable conditions. Such volumes are found occasionally in one or two lanes (usually those nearest the median), but average hourly volumes of this magnitude over all lanes are recorded too rarely to be considered as reasonably attainable.

The solid curves in the figure show the uninterrupted speed/flow relationships above the point of critical density (about 2,000 cars per hour). If uninterrupted flow is not maintained, an increase in flow causes the speed to decrease rapidly, with a marked simultaneous decrease in flow rate (dashed line in fig. C-11). For example, at a rate of flow

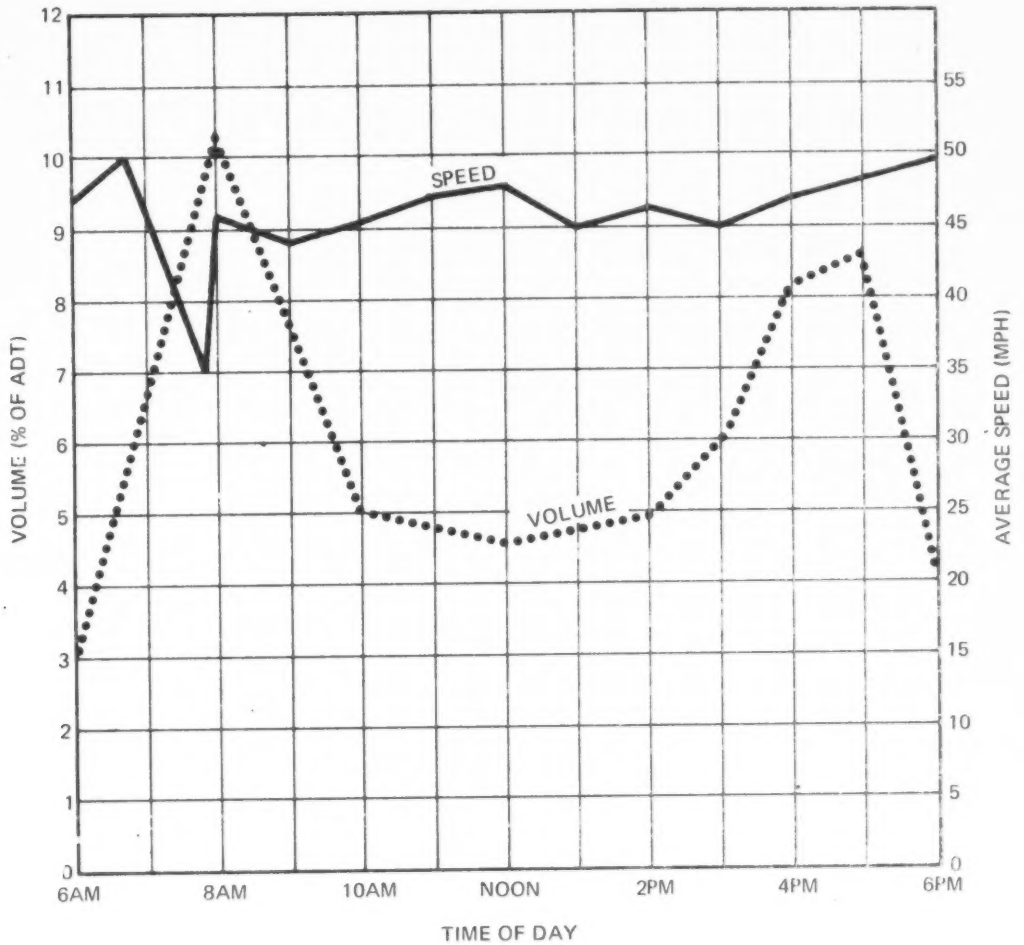

Figure C-10.—Example diurnal variation in volume and speed.
(From the "Highway Capacity Manual."[8])

of 1,400 vph per lane, the operating speed might range from 45 mph with free-flowing conditions to only 15 mph under highly congested, stop-and-go conditions.

It should be noted that since figure C-11 must be modified to reflect the unique limiting conditions of an actual roadway design, it should be used only as a *check* on the ideal capacity-operating characteristics of a proposed roadway.

If the volume/capacity (v/c) ratio is substituted for the absolute volume, the data in figure C-11 can be applied to any highway, of any number of lanes, for which the capacity can be determined, regardless of whether or not the associated conditions are ideal. Figure C-12 illustrates this fact, along with the basic limiting values of operating speed and v/c ratio that identify the several levels of service.

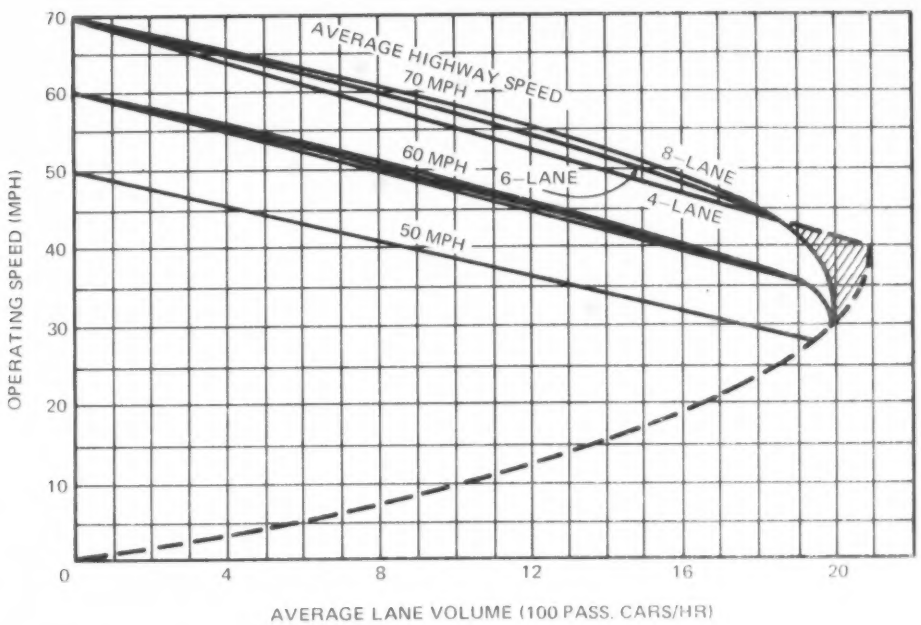

Figure C-11.—Typical relationship between volume per lane and operating speed in one direction of travel under ideal uninterrupted flow conditions on freeways and expressways. (From the "Highway Capacity Manual."[8])

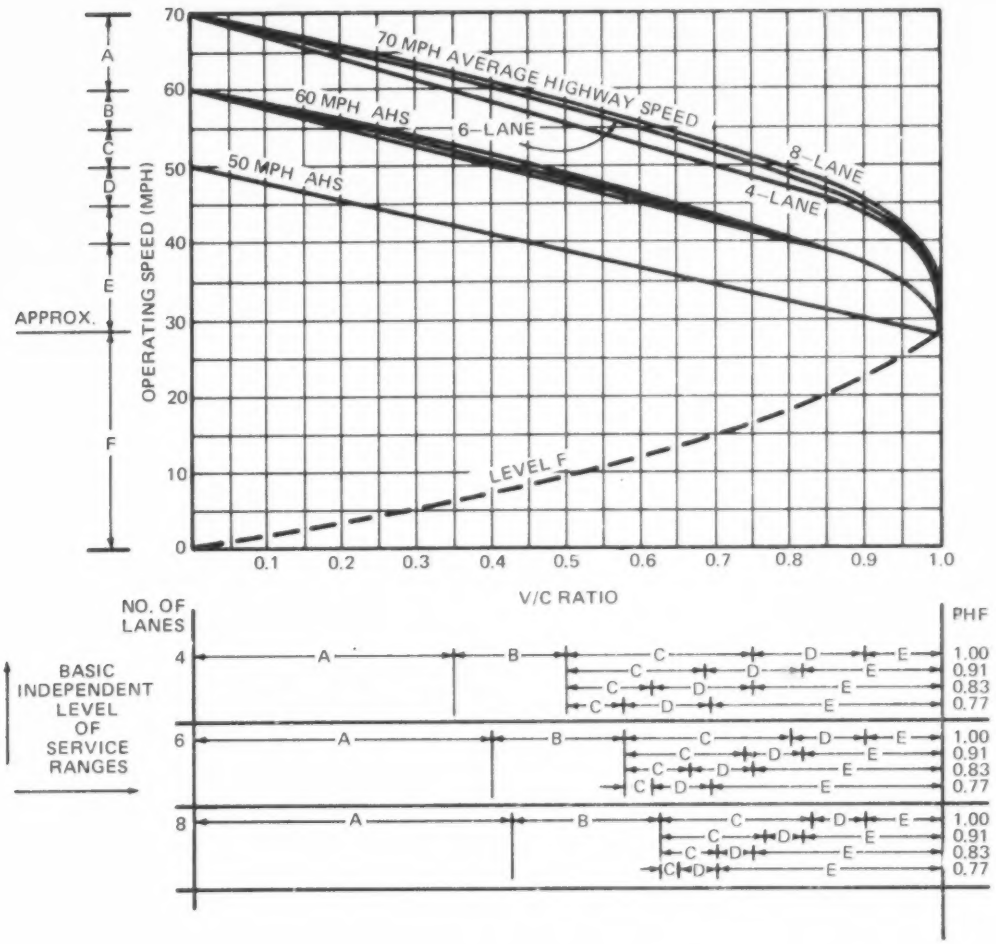

Figure C-12.—Relationship between v/c ratio and operating speed, in one direction of travel, on freeways and expressways, under uninterrupted flow conditions. (From the "Highway Capacity Manual."[8])